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ORIGINAL ARTICLES.

I.—Notes on new or imperfectly known Chalk Polyzoa.

By R. M. Brydone, F.G.S.

(*Continued from Dec. VI, Vol. III, p. 435.*)

(PLATE III.)

Membranipora crateroides, sp. nov. (Pl. III, Figs. 1 and 2.)

Zoarium unilaminate, incrusting.

Zoœcia large and pentagonal, average length about ·8 mm., markedly crater-shaped (i.e. with side walls sloping inwards to a deep-lying areal opening): areas sub-pentagonal as a rule: side walls wide, sloping inwards practically all the way from the zoœcial margin, the slope gentle in the lower half, then changing gradually to quite steep at the upper end; the two upper corners are occupied by a pair of stumpy perforated tubercles; just below the summit of the steep inward slope at the upper end of the arc, close to the corners and probably communicating with the external tubercles, are two pores so faint as to be hardly visible in full light.

Oœcia very large even for zoœcia of this size, and very globose; the only well-preserved specimens yet obtained have a jagged free edge which probably was once straight or slightly concave.

Avicularia very abundant; practically every zoœcium that has not an oœcium has above it a small, often sharply, equilaterally triangular accessory avicularium with well-preserved crossbar; in addition there are a number of sub-vicarious mandibular avicularia scattered irregularly about, and ranging from fully developed forms about ·45 mm. in length with the upper part of the beak expanded and rounded off down to forms about ·3 mm. in length with a short blunt beak projecting but little beyond a somewhat inflated body; occasionally these pass into a very remarkable form (Fig. 1) consisting of a greatly inflated body embracing the whole of a short beak and standing almost vertically on end.

This species is distinguishable from *M. trigonopora*, Marss.,[1] by its sub-vicarious avicularia and perhaps its oœcia, as none are recorded for Marsson's species, but they are obviously closely related. Like the species described in the previous paper it is prominent in the Weybourne Chalk; but it also occurs in the Norwich Chalk.

[1] Loc. cit., p. 58, t. v, fig. 16.

MEMBRANIPORELLA TÆNIATA, sp. nov. (Pl. III, Figs. 3 and 4.)

Zoarium unilaminate, free or incrusting.

Zoœcia very long, average length 1·2 to 1·3 mm., separated by a broad common wall running like a continuous ribbon between the lines of zoœcia and expanding to a great width between successive zoœcia: front wall pierced by numerous pairs of long very slender slits, the upper of which nearly meet in the middle line (in the early stages, Fig. 4, they may be much wider), highly arched, and rising steadily up to the greatly thickened final bar which forms the lower lip of the aperture and is markedly V-shaped and rests on the side walls distinctly beyond the areal margin: aperture large, roughly circular, but with straight sides which pass under the lower lip at a slight but distinct angle.

Oœcia apparently absent, which indicates affinity with the *Cribrilina Gregoryi* group.

Avicularia occurring freely embedded in the common wall; the great majority are of the small mandibular type characteristic of *Cribrilina Gregoryi*, and are arranged roughly in pairs above and below each aperture with others scattered about irregularly; but here and there occur much larger inflated and elongated forms with the aperture wholly in the upper half.

This species occurs in Hants in the upper part of the (restricted) zone of *A. quadratus*, but is quite rare.

MEMBRANIPORELLA BITUBULARIS, sp. nov. (Pl. III, Figs. 5 and 6.)

Zoarium unilaminate, free or incrusting.

Zoœcia long and narrow, average length ·8 to ·9 mm.: side walls often more or less distinct, but on the whole fused into a broad common wall which spreads out to a great width at the foot of the zoœcium and slopes gently down to the aperture of the preceding zoœcium: front wall flatly arched, pierced by numerous pairs of slits of which about the upper four are parallel and the remainder radiate, springing from just inside the top of the side walls and rising from the foot to within a short distance of the aperture, when it sinks again rather rapidly: aperture terminal, heel-shaped, and deeply sunk, with the straight lower lip thickened, but no thickened rim to the upper lip, much overshadowed, together with the side wall for some way above it, by lateral avicularia.

Oœcia absent, as is only to be expected in a species with such obvious affinity to *Cribrilina Gregoryi*.

Avicularia very regularly present in pairs on either side of the aperture as well as scattered irregularly along the side walls: the apertural pairs might be regarded as single rather large rounded accessory avicularia with abnormally stout crossbar in an unusually central position, but I think it much more probable that they are pairs of rudimentary avicularia in contact which have fused along the contact, the lower one being as a rule distinctly the larger.

This species is one of the very few which can be satisfactorily recognized among the various forms of this group, small numerically but great in variability, which occur in the *M. cor-testudinarium* zone of Sussex. The two specimens figured, of which the original of

Fig. 5 is the more typical, show how much variation is possible within the species.

CRIBRILINA TUMULIFORMIS, sp. nov. (Pl. III, Figs. 7 and 8.)

Zoarium unilaminate, incrusting.

Zoœcia very variable in shape, but on the whole long and very narrow for their length, like graves, often running to ·7 mm. in length with a breadth of only ·3 mm.; no side walls visible: front wall arched, with a sharply defined median ridge and numerous pairs of imperforate furrows which are very faint but seem to run nearly up to the median ridge; these furrows persist along the sides of the aperture: aperture terminal and small in proportion, without any thickened margin, almost circular with short and straight lower lip and a sub-quadrate upper lip with very faint upper angles and a very slight convergence to the lower lip; sometimes the lower lip is concave and the aperture is then practically circular; a pair of tiny tubercles occur at the upper angles, but are generally difficult to detect except when they have been absorbed by the oœcia (for which they act as starting-points) and re-exposed on the oœcia breaking. There is a communication slit at the extreme upper end.

Oœcia very abundant, elongated, slightly of the water-bottle type (with a constricted neck just above the aperture), and slightly pointed at the upper end, aperture small and semicircular, free edge distinctly concave; in a favourable light it can be discerned that these oœcia are ribbed like the zoœcia.

Avicularia do not appear to occur.

This species occurs sparingly in the *M. cor-anguinum* zone and the *Uintacrinus* band in Kent. It seems obviously an ancestor of *Cribrilina Filliozati*, Bryd.[1]

CRIBRILINA SEAFORDENSIS, sp. nov. (Pl. III, Fig. 9.)

Zoarium unilaminate, incrusting.

Zoœcia short and broad, average length ·4 mm.: no side walls visible, but from broken specimens they appear to remain quite distinct: front walls arched with numerous pairs of broad furrows, all radiating, which nearly reach the middle line, but are quite shallow and inconspicuous except near the margin, where they deepen rapidly: aperture terminal, lower lip formed by the slightly thickened terminal bar of the front wall, which is sometimes straight, sometimes gently concave; upper lip formed by a flatly curved segment of the unthickened side wall and bearing a pair of strong imperforate tubercles immediately adjoining the lower lip and in obvious continuation of the bases of those spines which have formed the front wall; above these tubercles the upper lip may bear, when there is no oœcium, one or two or even occasionally three minor tubercles; if there is an oœcium it starts immediately above the principal tubercles, and the lip of the aperture is cut away below it.

Oœcia rather large, globose on the whole but nearly straight-sided in the lower part; free edge slightly concave.

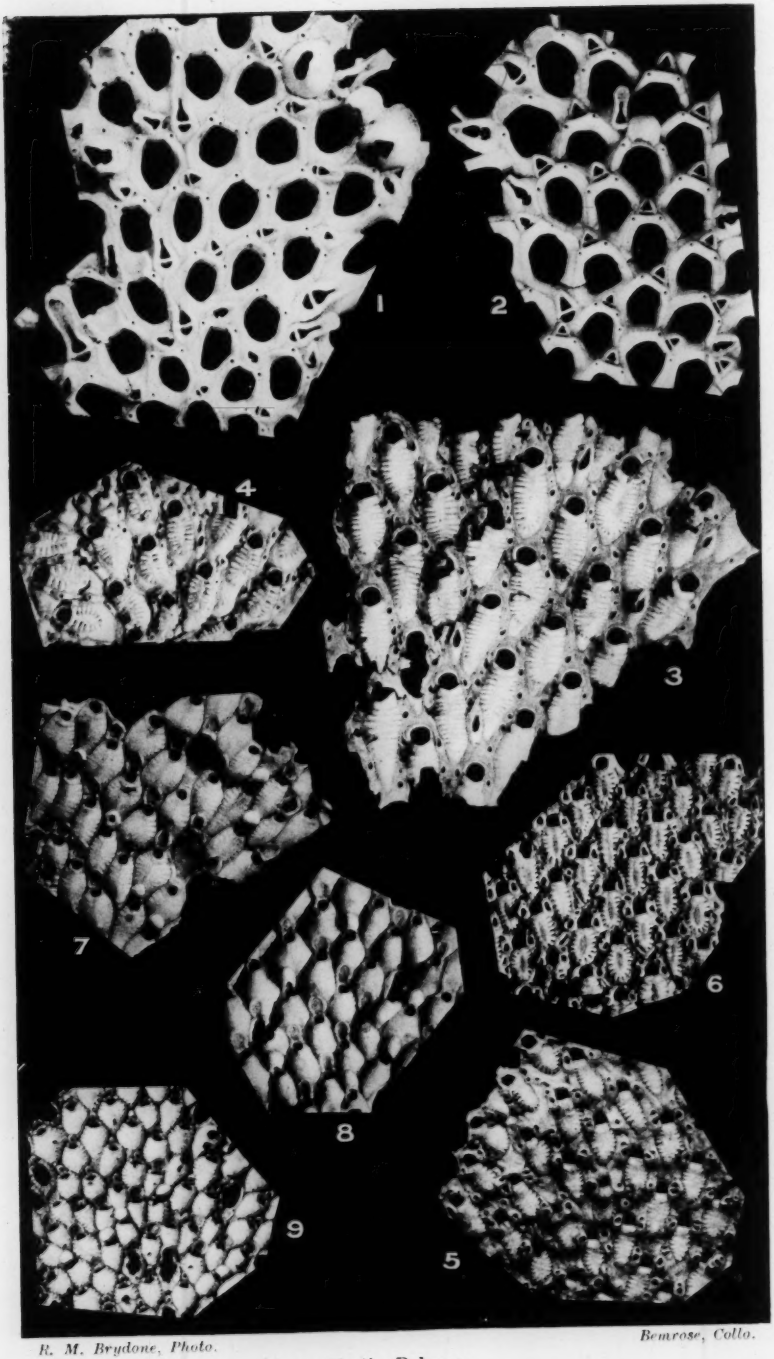
[1] GEOL. MAG., 1910, p. 391, Pl. XXX, Figs. 9, 10.

Avicularia tiny hoods with circular apertures placed immediately above the zoœcia in the middle line with great regularity when no œcium occurs; when there is an œcium the avicularium is suppressed or, very occasionally, displaced to one side; one or two instances in which they appear to have no aperture are probably due to the aperture being blocked by a fragment of shell.

This species is rare in the *M. cor-testudinarium* zone at Seaford. It illustrates well the building up of the Cribrilinid front wall from marginal spines, the bases of the spines being still distinguishable. It is probably ancestral to *Cribrilina cicatricifera*, Bryd.[1]

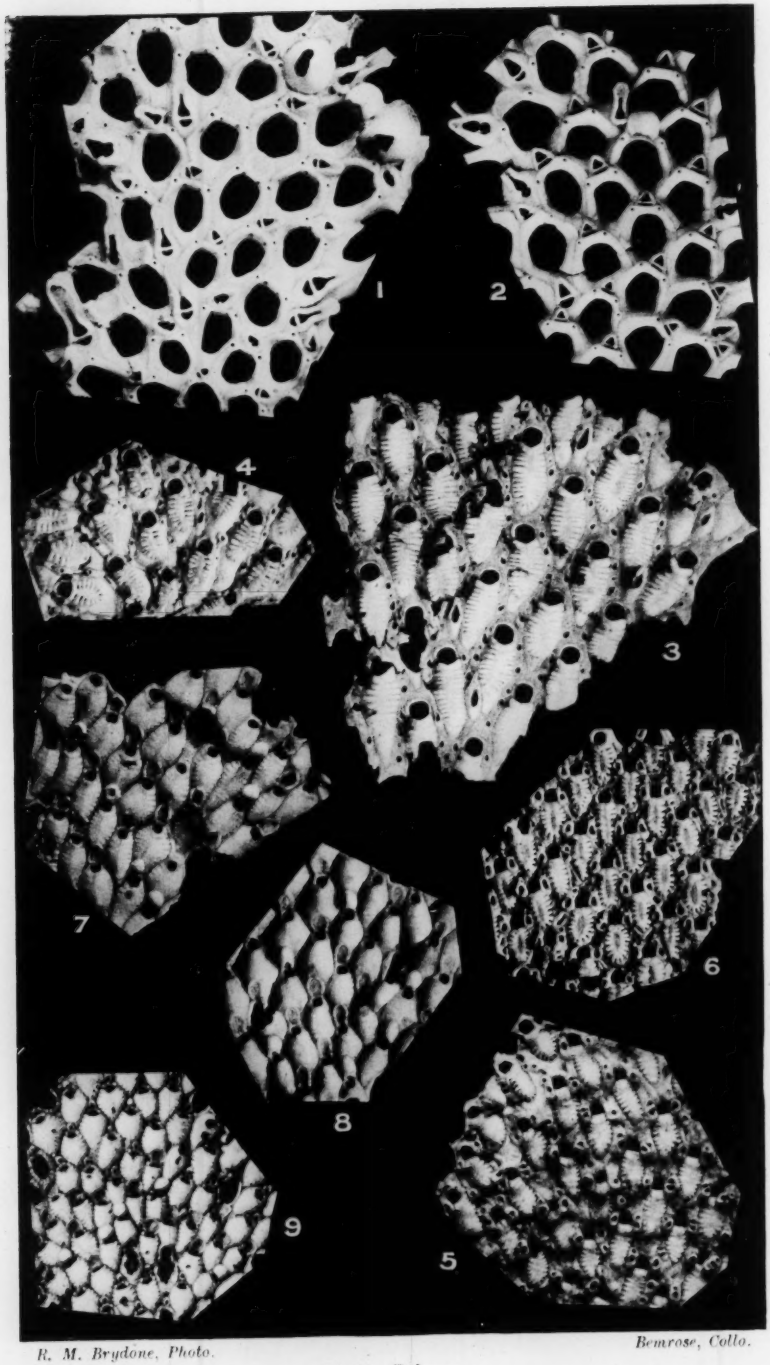
Since the above paper was framed I have seen Mr. Lang's Revision of the "Cribrimorph" (i.e. Cribrilinid) Cretaceous Polyzoa in *Annals and Magazine of Natural History* for July and November, 1916. I am glad to find that he adopts the view I propounded in 1906 (Geol. Mag., July, 1906, p. 289) that the characters by which the genera *Cribrilina* and *Membraniporella* are distinguished are not of generic nature. In replacing this principle of classification he has created over fifty new genera. It would obviously be a considerable task, for which I neither have time nor claim authority, to sit in judgment on such a volume of new material, particularly as it is not accompanied by a single illustration, and many of the new genera do not rest on any species figured elsewhere. It is fairly open to doubt whether as a rule any verbal description of characters among forms so small, numerous, and complex as the Polyzoa can be relied on as adequate definition of a new genus. The same consideration applies with even greater force to the very great number of new species which he catalogues without figuring any of them. It is not too much to say that the most detailed diagnosis without reference to a figure is now insufficient to identify any form among the vast crowd that either have already been adequately described or still remain to be so described. Mr. Lang's catalogues certainly do not amount even to detailed diagnosis, and it is impossible to treat his new species as identified sufficiently to be accepted as validly established. When they have been figured they will be sufficiently definite for useful study; but a cursory inspection of the catalogues suggests that some of them may have a hard struggle for existence unless the points which appear in the tabular diagnoses are substantially supplemented. It gives, for instance, a very retrograde impression to find unilaminar forms of *Cribrilina Gregoryi* divided solely by whether they grew incrusting an imperishable object or are now found free into two species (perhaps to be increased to three on Mr. Lang observing that though the majority of the free forms have a prickly reverse side a substantial minority are smooth). I shall also be much surprised if there should prove to be a bilaminar race of *Cribrilina Gregoryi*, that is, something more than an isolated freak or a unilaminar zoarium which has happened to incrust rather neatly the reverse side of a free unilaminar zoarium, at the horizon with which of all Chalk horizons I am perhaps most familiar.

[1] Geol. Mag., 1914, p. 97, Pl. IV, Figs. 1, 2.



R. M. Brydone, Photo. Bemrose, Collo.

Chalk Polyzoa.



R. M. Brydone, Photo. *Bemrose, Collo.*

Chalk Polyzoa.

EXPLANATION OF PLATE III.

(All figures × 12 diams.)

FIG. 1. *Membranipora crateroides.* Zone of *B. mucronata.* Weybourne.
" 2. " " " " Norwich.
" 3. *Membraniporella tæniata.* East Dean, Hants.
" 4. " Shawford, Hants.
" 5, 6. " *bitubularis.* Seaford. [Green, Kent.
" 7. *Cribrilina tumuliformis.* Zone of *M. cor-anguinum.* Leaves
" 8. " " " " Gravesend.
" 9. " *Seafordensis.* Seaford.

II.—The Age of the Maitai Series of New Zealand.

By C. T. Trechmann, M.Sc., F.G.S.

(PLATES IV AND V.)

Previous Views on the Age of the Maitai Series.

THE question of the age of the Maitai Series is one of the most important which concern New Zealand geology, and one which has aroused the greatest controversy and uncertainty. F. von Hochstetter,[1] before any distinctive fossils had been found in these rocks, considered that the "Maitai Series", which form the hills bounding on the east and south-east the strip of fossiliferous Trias of the Nelson area, were of Triassic age, and underlay the sandstones with *Monotis salinaria*.[2] In 1873 F. W. Hutton[3] referred the Maitai to the Jurassic on the supposed occurrence of *Inoceramus*. A. McKay[4] in 1878, during the survey of the Nelson district, found several fossils, obviously of late Palæozoic age, in the Maitai Limestone of the upper part of the lower Wairoa Gorge opposite a place called Martin's Saw-mill. Sir J. Hector[5] identified these as *Spirifera bisulcata*, *Productus brachythærus*, *Cyathophyllum*, and *Cyathocrinus*. McKay also surveyed and collected from the Maitai slates and argillites at Wooded Peak, on the Dun Mountain Tramway, some five miles east of Nelson. A large bivalve shell having the prismatic structure and general outline and concentric plication of *Inoceramus* occurs here. McKay, however, in his report adds that "there are material differences between this shell and the ordinary forms of *Inoceramus* which may warrant its being considered the type of a new genus". These words are of great importance, since he clearly states his conviction that fragments of a prismatic shell which occur with the Carboniferous fossils in the Maitai Limestones belong to the same shell as that which occurs in the slates on Wooded Peak. There can be no question but that it is the same shell. Since the finding of the above-mentioned fossils the Palæozoic age of the Maitai Series does not seem to have been seriously questioned till 1903, when Professor J. Park[6] stated his opinion that the Maitai Series

[1] F. von Hochstetter, *New Zealand*, 1867, p. 57.
[2] Now known as *Pseudomonotis Richmondiana*.
[3] Reports of Geol. Explorations, 1873–4, p. 34.
[4] Reports of Geol. Explorations, 1877–8, issued 1878, pp. 124, 132.
[5] Reports of Geol. Explorations, 1877–8, Introduction, p. xii.
[6] "On the Jurassic Age of the Maitai Series": Trans. N.Z. Inst., vol. xxxvi. p. 431.

are of Jurassic age. The reasons for this were, among others, the apparently conformable dip of the Triassic *Mytilus problematicus* beds in the Wairoa Gorge beneath the Maitai Limestone; the supposed equivalence of the Maitai Limestone with the Kaihiku Beds of Eighty-eight Valley; and the failure to find fossils in the Maitai Limestone. In 1910, however, Park,[1] after examining the limestone fossils collected by McKay in 1878, returns to the view that the Maitai Limestone is Carboniferous. He still, however, expresses doubts on the *Inoceramus* question, and says that "a careful search was made for fossils at the place where *Inoceramus* was said to occur, but without success". Some calcite-filled contraction rents were, however, found in the rocks, and it is suggested that McKay might have mistaken these for fossils. In 1911 a report[2] on the re-survey of the Dun Mountain district of Nelson by J. M. Bell, E. de C. Clarke, and P. Marshall appeared. In this report the whole of the Maitai Series, including its limestones, slates, argillites, and contemporaneous igneous rocks, together with the fossiliferous Trias of the district, including the Kaihiku, Oreti, Wairoa, and Otapiri Beds of the earlier reports, are included together as a conformable series of Trias–Jura age, and are spoken of as the Maitai Series. The inclusion together of all these beds was due partly to the unfortunate fact that again the surveyors failed to detect the fossils in the Maitai Limestone previously recorded by McKay, but also because of the deceptive appearance of conformity between the Trias and the Maitai. P. Marshall in 1912[3] repeats his opinion that the rocks from the Dun Mountain to the Waimea Plain are a conformable series, but are sharply folded, and attributes a Trias–Jura age to the whole series.

In October, 1915, when I was in the Wairoa Gorge in company with Mr. F. Worley of Nelson, we made careful inquiries where "Martin's Saw-mill" formerly stood, as it had disappeared since 1878. On returning two days later with Dr. A. Thomson we had the good fortune almost simultaneously to find the fossils at the place indicated. I also found an exposure of the same limestone, on the bank of the Roding River, just above the point where it joins the Wairoa River, which showed the sections of a fair number of fossils on the water-worn surface of the rock. A fairly large collection was made here by Dr. Thomson and myself, and we obtained a few forms in addition to those found in 1878.

Two days later I visited, in Mr. Worley's company, the Dun Mountain tramway line, and at Wooded Peak, again following closely the instructions in McKay's report, we found the large bivalves, exactly as he had described, in the slaty argillites, just west of a limestone band which adjoins the great serpentine and dunite intrusion of the so-called Mineral Belt. Having found the fossils, I paid special attention to collecting hinges or other portions

[1] *Geology of New Zealand*, 1910, p. 50.

[2] *The Geology of the Dun Mountain Subdivision, Nelson*, Bulletin No. 12 (New Series), 1911, p. 21.

[3] *Handbuch der regionalen Geologie* (Heidelberg): New Zealand and adjacent islands. English reprint, Heft v, Bd. vii, Abt. i, p. 16.

which might decide the question whether the shell is really *Inoceramus* or not.

Structure and Tectonics.

The Maitai Beds are a series of great structural importance since they, or at any rate rocks referred to this series on lithological and stratigraphical grounds, enter largely into the composition of the Alpine ranges of the South Island. It is only, however, in the Nelson district where fossiliferous limestones occur in the Maitai that any fossils other than the prismatic shell fragments and possibly some annelid tubes have been found in these beds.

McKay records nine localities where fragments of this prismatic shell have been found. Similar fragments occur in limestone on the Cass River and the Upper Waimakariri in the Canterbury Alps.[1]

The relation of the Mt. Torlesse annelid beds, which by the way are said not to occur actually at Mt. Torlesse, to the Maitai Series is one of the most difficult problems of New Zealand geology. McKay discusses this question,[2] and the general opinion seems to be that the annelid-bearing rocks belong to the upper part of the Maitai Series.

A great series of greywackes and other beds forms the ranges of the Rimutaka, Ruahine, and Tararua Mountains on the eastern side of the North Island. Dr. Thomson has recently found annelid remains in these beds near Wellington.

In other places the Maitai Beds become partly or completely metamorphosed. McKay[3] reports their occurrence in a semi-metamorphic condition in the heart of the Southern Alps west of Lake Whakatipu. When in this condition they are not easily distinguished from the underlying or partly equivalent Te Anau Series. However, both the Te Anau and the Maitai Series are newer than the rocks which at Mt. Arthur and Reefton contain a Silurian or possibly Devonian fauna.

McKay, after a detailed study of the Nelson area concludes, though with considerable reserve, that the Maitai Beds are arranged in a syncline with the main axis N.N.E. and S.S.W., in which case the limestone must underlie the slates and argillites of Wooded Peak. This limestone crops out near the top of the lower part of the Wairoa Gorge, where it forms the eastern boundary of the fossiliferous Trias beds. A limestone again appears on the eastern side of the slates and argillites on Wooded Peak, five miles east of Nelson, where, though unfossiliferous, it strongly resembles that of the Wairoa Gorge, and I have little doubt is the same bed.

No locality is known in New Zealand which reveals clearly the relation of the Trias to the beds underlying it. The Nelson area, the critical one for the study of the Maitai Beds, is very complicated. The Trias beds which form the foot-hills seem to consist of a long faulted synclinal strip, to the east of which, between them and the serpentine and dunite intrusion of the so-called Mineral Belt, the

[1] McKay, "Ashley and Amuri Counties": Rep. Geol. Expl. for 1879–80, issued 1881, p. 88.

[2] Ibid., pp. 89–90.

[3] Ibid., "Lake County," p. 142.

Maitai Beds, as remarked above, form another syncline. Both these parallel synclines appear to have been faulted and thrust over towards the west or north-west, with the result that the Trias appears to dip below the Maitai Limestone. Some zones of the Trias are locally missing through being faulted or thrust out, and the Tertiary beds which bound the Trias to the north-west along the edge of the Waimea Plains are forced up on end along the junction.

Lithology.

The Maitai Limestone in the Wairoa Gorge is much jointed, fissured, slickensided, and crushed, and has many veins running through it, which are sometimes seen to be repeatedly faulted on a small scale. Some parts are very impure, containing quartz grains and spots of a serpentinous or glauconitic mineral in such quantity that very little calcite remains and the rock becomes decalcified to a considerable depth. It is splintery in places but very hard in others. The greater part is unfossiliferous; the fossils appear to be confined to the upper part, where it adjoins the Maitai slates and greywackes to the east. Little clusters of prismatic shell fragments, however, occur lower down. The fossils are very closely incorporated with the rock, and are in consequence difficult to detach and are best collected in the decalcified portions. I had a slice made of a portion of the rock which contained a cluster of prismatic shell fragments (Plate IV, Fig. 8). It contains many fragments with corroded edges, and the surrounding matrix is also largely made up of isolated prisms of the decomposed shell which seem to be arranged round the larger pieces in a sort of flow-structure, or this may be a later pressure effect. A cross section of the prisms shows that they are more or less octagonal in outline. The matrix also contains quartz grains and chloritic specks.

The thickness of the limestone in the Wairoa Gorge is estimated at 2,000 feet,[1] but at Wooded Peak it is reduced to about 1,000, while southwards it gradually thins out and is finally represented by calcareous slates. It dips everywhere very steeply, often vertically. It seems impossible at present to estimate with any accuracy the thickness of the slates and argillites and the other beds which form the Maitai Series, but it is undoubtedly very great. The beds at Wooded Peak form a great series of hard, thinly bedded, well-jointed grey argillites, which dip everywhere nearly vertically. The large flattened shells are difficult to see and are easily overlooked on the weathered and moss-grown surfaces of the rock, but the sections of them can be detected on examining the joint faces, and the application of a hammer and chisel soon brings them to light. They are chiefly located along one or two bands quite near the adjoining limestone.

Fossils of the Maitai Rocks.

Aphanaia sp. (Pl. IV, Figs. 1–4.)

A glance at Figs. 1, 3, and 4 will show that the hinge of the large bivalve of Wooded Peak is not that of *Inoceramus*, but the genus of this shell is not easy to determine beyond doubt. I am of the

[1] McKay, "Report on the Wairoa and Dun Mt. Districts": Rep. Geol. Expl. for 1877–8, issued 1878, p. 135.

opinion, for the following reasons among others, that it belongs to the Myalinid genus *Aphanaia*,[1] de Kon., two species of which have been described from the Permo-Carboniferous of Australia :—

1. The type-specimens of the genus described by de Koninck were only casts, and consequently, as he remarks, the structure of the shell could not be ascertained. However, I obtained during the British Association excursion to the Maitland Coalfield in 1914, a specimen of *Aphanaia* cf. *Mitchelli*, from the lower marine beds of Harpers Hill, New South Wales. This specimen has the two valves in apposition, and is damaged, but part of the hinge and portions of the shell remain. The shell is prismatic in structure as it is in the case of the New Zealand fossil, and is made up of rows of upright prisms standing at right angles to the surface of the valves just as is the case in *Pinna* or *Inoceramus*.

2. The shape of the shell agrees with that of *Aphanaia*. The beaks of *Aphanaia* are anterior or terminal, and in one species are described as recurved. The hinge-line is straight or slightly bent and makes practically a right angle with the anterior margin of the shell, and there is no trace of an anterior ear. These features apply equally well to the New Zealand fossil.

The fact of de Koninck's original specimens being casts makes a close comparison a matter of some uncertainty, but apart from this the only thing which would cause me to hesitate in this attribution is that I have not been able to see the muscle-scars in the New Zealand shell. These in the Australian forms are said to be very large and pronounced, but the shells I collected at Wooded Peak are so crushed and fractured that the muscle impressions seem to have become obliterated. Only the harder and thicker region of the beaks remains more or less unbroken in the rock; the rest of the large and thin shell is crushed into small pieces, which, however, are not displaced to any extent.

I only found the separated valves at Wooded Peak, but obtained specimens from which I was able to make gutta-percha squeezes of the beak and hinge area of both right and left valves. Among the specimens which Mr. McKay collected, however, there is one which has the apex of the opposite valve in position, but I cannot say if the two valves were equal in size or not. The largest specimen I collected measures 170 mm. long and 95 mm. high. The beaks are rounded or boss-like, are nearly or quite terminal, recurved so as to face one another and stand straight above the anterior end of the hinge-line. The hinge area is broad and long, and is marked by shallow parallel longitudinal grooves separated by almost equally wide ridges.[2] The hinge-line forms an obtuse rounded angle with the posterior part of the shell, but a right angle with the anterior margin. The anterior portion of both valves in front of and below the beaks is folded inwards, and there appears to be a retreat of

[1] *Descriptions of the Palæozoic Fossils of New South Wales*, Eng. trans. (Mem. Geol. Surv. N.S.W.), Palæontology, No. 6, 1898, p. 238, pl. xxi, figs. 5, 6.

[2] This structure is, of course, quite different from that of *Inoceramus*, which has a row of vertical ligament pits on the area.

the margin so that when the two valves were together a byssal opening was produced. The surface is ornamented with a series of broad and very irregular concentric furrows and ripples.

The New Zealand specimens[1] are hardly sufficiently well preserved to justify a specific determination, but they seem to agree in most of their features with *Aphanaia Mitchelli*, F. McCoy sp., of the Upper Marine Permo-Carboniferous of various localities in New South Wales. The larger species, *A. gigantea*, de Kon., seems to differ in the boat-like shape of the larger valve and the greater obliquity of the hinge-line.

Platyschisma sp. (Pl. V. Fig. 9.)

The shell has a depressed spire and consists of four or possibly five whorls, which are smooth and rounded and increase rapidly in size. The last one is rather angular below, and the shell structure is fibrous. Owing to its poor state of preservation the growth-lines can scarcely be detected, neither could the umbilicus be clearly seen, but after examining the fragments of another specimen I think that there was a shallow umbilicus. Both in outward shape and in the fibrous structure this shell has every appearance of identity with *Platyschisma* of the Permo-Carboniferous marine beds of New South Wales, and seems to agree more closely with *P. rotunda*,[2] Eth., than with the more common *P. oculus*, Sow.

Locality.—Maitai Limestone, upper end of the Wairoa Gorge, in the side of the stream where the Roding joins the Wairoa River. The figured specimen was collected by Dr. Thomson. I found another close to the first one, but in a still poorer state of preservation.

Pleurotomaria or *Mourlonia* sp. (Pl. V, Fig. 10.)

A piece of limestone full of fragments of the prismatic bivalve shows on its weathered surface the outline of a small Gasteropod having four keeled whorls. The keel passes round the middle of the last whorl and lies above the suture in the penultimate whorl. The shell is weathered away, but in outline suggests a small *Mourlonia*.

Various small *Pleurotomariæ* are recorded from the Permo-Carboniferous of Australia and the Salt Range, but none seem quite so strongly keeled as the present form.

Strophalosia sp. (Pl. V, Figs. 4, 5.)

Hector records *Productus brachythærus* among the fossils obtained from the Maitai Limestone, but on examining the specimens

[1] I may here remark that in consequence of the occurrence of annelid-like tubes in the Maitai Limestone similar to those in the Mt. Torlesse beds and in the Yakutat slates of Alaska I suspected that the genus *Inoceramya*, Ulrich, from the latter beds might be similar to the New Zealand shell. But on looking up the description of this shell in the report of the Harriman Alaska Expedition, I found that it is quite different and possesses a series of vertical ligamentary pits and is undoubtedly closely related to *Inoceramus*. The Yakutat slates seem to be of Liassic age.

[2] Jack & Etheridge, *Geology and Palæontology of Queensland*, 1892, p. 286, pl. xv, fig. 6.

belonging to the Survey upon which his identification must have been based I see that they are really *Strophalosia*. The narrow area in both dorsal and ventral valves as well as the dental sockets in the dorsal valve are clearly apparent, and there is a large and prominent cardinal process.

The specimens are too imperfect to make any sure specific determination. In one specimen, Fig. 5, the shell is rather wider than long. The dorsal and ventral valves are strongly concavo-convex, and the dorsal valve has a rather foliaceous surface and the spines are short and curved. I have some *Strophalosias* from the Upper Marine Permo-Carboniferous of Maria Island, Tasmania, which rather resemble the New Zealand form. Taking into consideration the concavity of the dorsal valve and other features, the only described Australian form which it resembles in these respects is *S. Gerardi*, King, an Indian species which Etheridge records from various localities in Queensland and Tasmania.[1] King's figures of this Himalayan form are very like one of the New Zealand examples, Fig. 5.

Locality.—Maitai Limestone, Wairoa Gorge. I saw many sections of *Strophalosia* in the limestone near Martin's Saw-mill.

Rhynchonella (*? pugnax*) cf. *pleurodon*, Phill. (Pl. V, Figs. 6–8.)

Several casts of a small Rhynchonellid were obtained from the decalcified portions of the Maitai Limestone, from which I made gutta-percha squeezes. The beak is pointed, rather prominent, and slightly bent over, and has a well-marked triangular area. There are eleven or twelve ribs on the dorsal valve, which commence at the apex; the middle four or five ribs are straight, but the lateral ones are slightly curved, and the intervening furrows are deep and angular. The mesial ventral sinus and dorsal fold are only very slightly indicated. It is impossible to see anything of the internal structure.

This form agrees very closely in outward appearance with the above species, and is comparable with a specimen figured by Davidson (pl. xxiii, fig. 11), but is less alate and has a rather more prominent beak. It also resembles, except for the slight differences mentioned, an Australian Permo-Carboniferous specimen figured by Koninck.[2]

Martinia (*Martiniopsis* ?) *subradiata*, G. Sow. (Pl. V, Fig. 3.)

Hector recorded *Spirifer glaber* from Maitai Limestone, but I did not see the specimen upon which his identification was founded. However, I collected a single ventral valve of a smooth Spirifer which exactly resembles externally the ventral valves of specimens that I obtained from the Upper Marine Permo-Carboniferous of Branxton and Gerringong in New South Wales. The median sinus is broad and shallow, and is continued to the apex. The rest of the shell is rounded and has a rather foliaceous surface with two or three very faint rounded lateral ribs. The hinge-line is considerably less than the width of the shell.

[1] Jack & Etheridge, *Geology and Palæontology of Queensland*, 1892, p. 260.
[2] *Palæozoic Fossils of New South Wales*, p. 170, pl. ix, fig. 4.

It is impossible to remove the hard rock to see if the large and thick hinge-teeth and dental plates are present as they are in the Australian equivalents of *Spirifer glaber*, and so the absolute identity of the New Zealand with the Australian forms cannot be demonstrated.

Waagen suggested that the Australian forms of *Spirifer glaber* might belong to his genus *Martiniopsis*,[1] and this supposition is followed by Etheridge[2] apparently on the strength of Waagen's remarks. I am very doubtful whether these forms are sufficiently akin to Waagen's Salt Range genus to justify us in calling them *Martiniopsis*, in which the dental and septal plates are long and narrow and do not seem to be accompanied by a shelly infilling of the beak region. The ribbed Spirifers in the Australian Permo-Carboniferous and the New Zealand form of *Spirifer bisulcatus* are also similarly thickened in the beak of the ventral valve. Many phyla of Brachiopods develop excess of shelly matter towards the end of their existence, and it must be remembered that the Australian Permo-Carboniferous marine bands are probably of Artinskian age and very much younger than the English and Belgian Visean Lower Carboniferous.

Locality.—Maitai Limestone, junction of Wairoa and Roding Rivers.

Spirifer cf. *bisulcatus*, J. Sow. (Pl. V, Figs. 1, 2.)

Only one species of ribbed Spirifer seems to occur in the Maitai Limestone, and in outward appearance it agrees with *S. bisulcatus* as Hector originally identified it. It does not lend itself to a very close comparison with any of Davidson's figures, but strongly resembles an Australian specimen figured by de Koninck.[3]

The hinge-line is the greatest width of the shell. In the ventral valve the median sinus is continued to the apex, and is broad and shallow, and merges gradually into the rest of the shell. The ribs are closely set, narrow, rounded, equally spaced, and are similarly developed on the furrow as they are on the rest of the shell. I have no specimens which show clearly the exterior of the dorsal valve.

The interior of the ventral valve is much thickened posteriorly by deposition of shelly matter, but the dorsal valve does not seem to be thickened. The dental plates in the ventral valve are strong and heavy, and the space between them and the area is much thickened. The hinge-teeth correspond to wide and deep sockets in the dorsal valve. The thickening of the ventral valve makes it appear that the Australasian forms bear the same relation to the Northern *S. bisulcatus* as the so-called *Martiniopsis subradiata* does to the European lower Carboniferous *Spirifer glaber*, and that the similarity in exterior ornamentation does not denote specific identity.

Zaphrentis sp. (Pl. IV, Figs. 5–7.)

A selection of the few corals from the Maitai Limestone in the collection of the New Zealand Survey was sent to Dr. A. Vaughan

[1] "Salt Range Fossils": 1, *Productus* Limestone Fossils: Pal. Ind., ser. XIII, vol. iv, fasc. 2, p. 525, 1883.

[2] *Palæontology and Geology of Queensland*, 1892, p. 237.

[3] *Palæozoic Fossils of New South Wales*, pl. xiv, fig. 5c.

some years ago. No report on them has appeared, and as a result of his death the specimens cannot now apparently be traced. However, I found a specimen still remaining in the collection, Dr. Thomson found another in the Maitai Limestone, and I collected a third quite satisfactorily preserved specimen showing the sharp rim of the calyx and other features. All that I have seen are forms of *Zaphrentis*.

The specimen I collected (Fig. 7) must have measured about 55 mm. in length. The breadth at the top was about 25 mm. and the depth of the calyx 16 mm. The corallum is turbinate and almost circular in section, and the edges of the calyx are sharp. A section made slightly below the calyx shows that the fossula reaches slightly beyond the centre, and there are about forty-two septa, which are slightly sinuous and do not all reach the centre. The septa are about equally thick and maintain this thickness in their whole length. The outer ends fuse to form a quite thick thecal wall. The fossula is divided by a septum to about half its length from the outer wall. Three or four thin irregularly spaced dissepiments are seen joining each pair of septa.

This coral rather resembles *Z. Gregoryana*, de Kon.,[1] which occurs in the Permo-Carboniferous of Jervis Bay, N.S.W., but in that form the septa number thirty-six and are stated to be thicker at the outside than at the inside.

Another coral (Figs. 5, 6) is more oval in section. The septa number about 68 or 70, and are irregularly sinuous and wavy and are more or less regularly and alternately thick and thin. The septa all reach the fossula, which extends to slightly beyond the centre, and is divided along its whole length by a thin median septum, with a shorter but equally thin lateral septum on either side. The septal ends fuse to form a fairly thick outer wall, which, however, is partly eroded.

Locality.—Both these corals occurred in the Maitai Limestone at the junction of the Wairoa and Roding Rivers.

[Since writing the above I have received the following note on the coral sections from Mr. Stanley Smith, D.Sc., F.G.S., who has kindly examined the specimens for me:—"Both specimens may be safely assigned to the genus *Zaphrentis*, although it would not be wise to compare them with any British species, especially since they have undergone considerable mineral change. The specimens appear to represent two distinct species rather than two growth stages of a single species. The larger specimen (Fig. 7) displays a large and conspicuous cardinal fossula, the septa are not crowded, and there is a well-developed dissepimental zone. In the smaller specimen (Fig. 5) the fossula is distinct but not prominent, the septa are numerous and crowded, and there is no dissepimental zone. The latter may have perished or may be undeveloped at the stage growth represented by the section. In the two sections only the major septa are developed; in Fig. 5 the septa are dilated and split by mineralization, so that the first impression is that of thin septa alternately long and short; the shorter line is the medial 'dark line' of the septa."—S. S.]

[1] *Palæozoic Fossils of New South Wales*, pl. v, fig. 7.

Serpulites (?) sp. (Pl. V, Fig. 11*a*, *b*.)

A fragment, 5 mm. long, of a tubular organism, now siliceous, but probably originally calcareous. It is almost circular in section at one end, where it measures 5 mm. in diameter, but slightly oval at the other. Its outer surface seems to be rather rough. This organism suggests the tubular structures called *Torlessia McKayi*, Bather,[1] which occur in the Mt. Torlesse Annelid beds, and which most New Zealand geologists consider the highest member of the Maitai Series.

It also suggests *Serpulites Warthi*,[2] Waagen, which is said to be very common fossil in the Lower Speckled Sandstone and the glacial Boulder Beds of the Salt Range, the fauna of which is equivalent to that of the marine Permo-Carboniferous of Australia and the Maitai fauna of New Zealand.

Locality.—Maitai Limestone, junction of Wairoa and Roding Rivers, Wairoa Gorge.

All the ten genera and species I have described, with the exception of the comparatively unimportant Serpulites, occur in the marine Permo-Carboniferous of New South Wales.

The evidence, therefore, of the fossils of the Maitai rocks, few as they are, is overwhelmingly in favour of a correlation of these beds with the marine Permo-Carboniferous of New South Wales and Tasmania.

The absence of certain familiar fossils of Australia and the Salt Range, such as *Eurydesma*, *Conularia*, *Aviculopecten*, etc., may be noticed, but their absence may be explained on geographical or bathymetrical grounds. The Boulder Bed of the Salt Range is equally wanting in some forms, but Waagen does not hesitate to correlate its fauna with that of the Permo-Carboniferous of Australia.

The Relation of New Zealand to Gondwanaland.

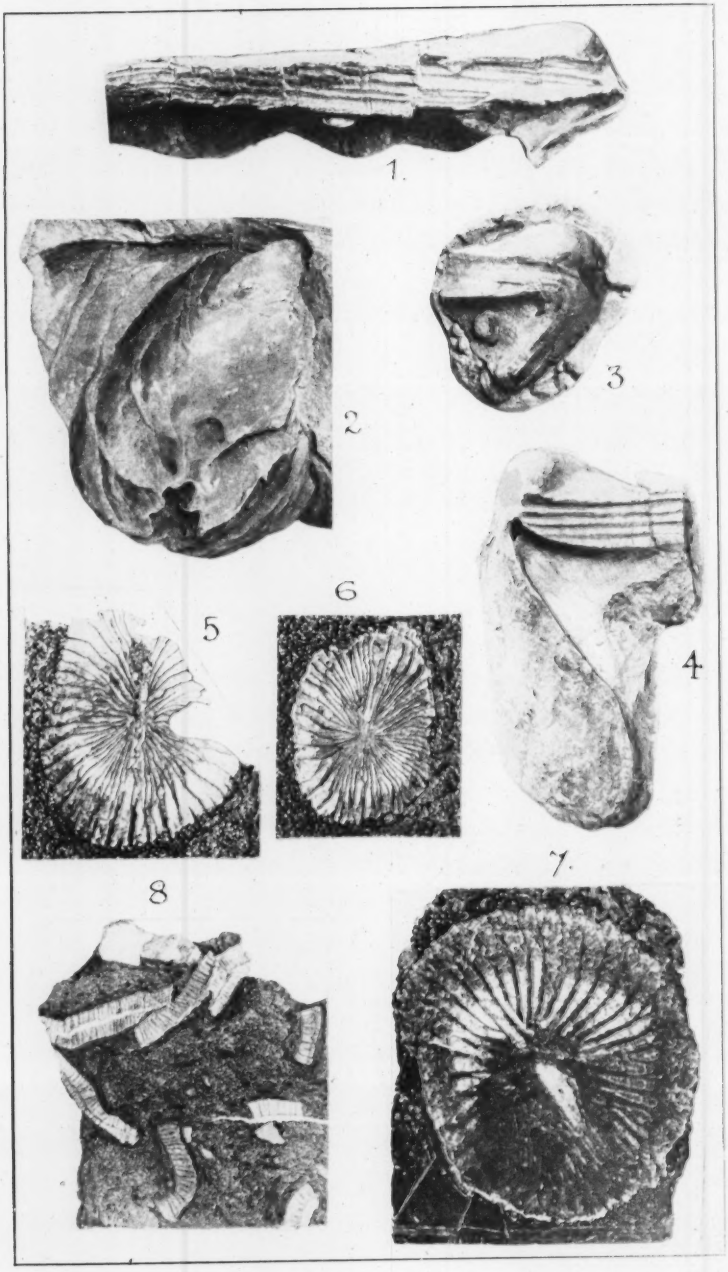
The attribution of the fossils of the Maitai Series to a Permo-Carboniferous age, equivalent to the marine bands in the Permo-Carboniferous of New South Wales and Tasmania, raises the question both of the presence or absence of a *Glossopteris* flora, and of the relations of the New Zealand area to Gondwanaland.

Mr. E. A. N. Arber[3] has shown that the flora of the Mt. Potts Beds of the Canterbury Alps, which Hector supposed to contain *Glossopteris*, is really of late Trias or Rhætic age, and the supposed *Glossopteris* is a new genus which he calls *Linguifolium*, allied to certain plants in the Rhætic of Chili. This result agrees on the

[1] "The Mount Torlesse Annelid": Geol. Mag., Dec. V, Vol. II, pp. 532–41, 1905.

[2] "Salt Range Fossils": Geological results: Pal. Ind., ser. xiii, vol. iv, pt. ii, p. 135, pl. iii, figs. 5, 6*a*, *b*, 1891.

[3] "Preliminary Note on the Fossil Plants of the Mount Potts Beds, New Zealand": Proc. Roy. Soc., B, vol. lxxxvi, pp. 344–7, 1913. Mr. Arber remarked to me in a letter that even if *Glossopteris* should be found at Mt. Potts, which is extremely improbable, it would not mean that the beds are Permo-Carboniferous, since *Glossopteris* occurs in Rhætic beds in Tonkin and China. The Mt. Potts flora is a Mesozoic one "beyond redemption".



MAITAI LAMELLIBRANCH: CORALS.

whole with my independent determination of the Kaihiku marine fauna, which is associated with the plant beds at Mt. Potts as of late Middle or early Upper Trias age.

Since no trace of *Glossopteris* or any other plant is recorded from the Maitai rocks the palæobotanical evidence is removed. Further, although several coarse conglomerates occur in the Maitai Series, nothing for which a glacial origin can seriously be claimed has been found. The Permo-Carboniferous of New Zealand differs from that of South Africa, the Salt Range, Australia, Tasmania, the Falkland Islands, South America, or other regions of Gondwanaland in the absence of glacial beds or of a *Glossopteris* flora. There is no trace in New Zealand of a non-marine plant-bearing Permo-Carboniferous series, and there seems no prospect of any turning up. The beds appear to be entirely marine, but were evidently deposited not far from some land mass of continental dimensions.

The conclusion, therefore, is that although the New Zealand area formed no actual part of Gondwanaland, it lay during the Permo-Carboniferous period not far from the shores of this or some similar great land mass which supplied the materials which build up the Maitai Series.

In no part of New Zealand has definite[1] evidence of any unconformity between the Maitai and the Trias been found, and so it is possible that uninterrupted marine conditions persisted from the Permo-Carboniferous times through the Trias and on into the Jurassic period.

EXPLANATION OF PLATES IV AND V.

(All figures natural size except where otherwise indicated.)

PLATE IV.

FIG.

1.—*Aphanaia* sp., cf. *Mitchelli*, F. McCoy, sp. Hinge and area of left valve. Nat. size. Gutta-percha squeeze. Maitai Slates, Wooded Peak, near Nelson. Author's collection.

2.—Ditto. Cast of right valve of a small specimen showing the concentrically furrowed shell. Nat. size. Dun Mountain Tramway, near Nelson. New Zealand Geol. Surv. collection.

3.—Ditto. Gutta-percha squeeze of apex of a left valve. Nat. size. Maitai Slates, Wooded Peak, near Nelson. Author's collection.

4.—Ditto. Gutta-percha squeeze of apex and part of the area of a right valve. Nat. size. Maitai Slates, Wooded Peak, near Nelson. Author's collection.

5.—Section of *Zaphrentis* sp. Magnified 2 diameters. Maitai Limestone, junction of Wairoa and Roding Rivers, Wairoa Gorge. Dr. Thomson's collection.

6.—Section of the same coral cut rather lower down.

7.—Section of *Zaphrentis* sp., cf. *Gregoryana*, de Kon., cut just below the calyx. Magnified 2 diameters. Maitai Limestone, junction of Wairoa and Roding Rivers, Wairoa Gorge. Author's collection.

8.—Section of Maitai Limestone from the Wairoa Gorge with a cluster of prismatic fragments of the large bivalve *Aphanaia*. Author's collection.

[1] The reported occurrence of an unconformity between the Kaihiku and Takitimu Series in the Takitimu Ranges seems to require further investigation. Cox, Rep. Geol. Explorations, 1877–8, "Geology of the Te Anau District," p. 113.

FIG. PLATE V.

1.—*Spirifer* cf. *bisulcatus*, J. Sow. Ventral valve. ½ nat. size. Maitai Limestone, Martin's Saw-mill, Wairoa Gorge. New Zealand Geol. Surv. collection.

2.—Ditto. Internal cast of ventral valve in decalcified rock. Nat. size, showing the thickened interior of the ventral valve and dental plates. Same locality. New Zealand Geol. Surv. collection.

3.—*Martinia* (*Martiniopsis*?) *subradiata*, G. Sow. Ventral valve. Nat. size. Maitai Limestone, junction of Wairoa and Roding Rivers, Wairoa Gorge. Author's collection.

4.—*Strophalosia* sp. Interior of dorsal and beak of ventral valve. Nat. size. Maitai Limestone, Martin's Saw-mill, Wairoa Gorge. New Zealand Geol. Surv. collection.

5.—*Strophalosia* sp., cf. *Gerardi*, King. Gutta-percha squeeze of exterior of dorsal valve, ventral beak, area, etc. Nat. size. Same locality, in decalcified rock. New Zealand Geol. Surv. collection.

6–8.—*Rhynchonella* (*pugnax*) cf. *pleurodon*, Phill. Gutta-percha squeezes of parts of dorsal and ventral valves, area, etc. Nat. size. From decalcified limestone at Martin's Saw-mill. Wairoa Gorge.

9.—*Platyschisma* sp., cf. *rotunda*, Eth. Nat. size. Maitai Limestone, junction of Wairoa and Roding Rivers, Wairoa Gorge. Dr. Thomson's collection.

10.—*Pleurotomaria* (?) or *Mourlonia* sp. × 4.

11*a*, *b*.—*Serpulites* (?) sp. Maitai Limestone. *a*. section; *b*. side-view of tube. × 3.

III.—The Rhythmic Deposition of Flint.

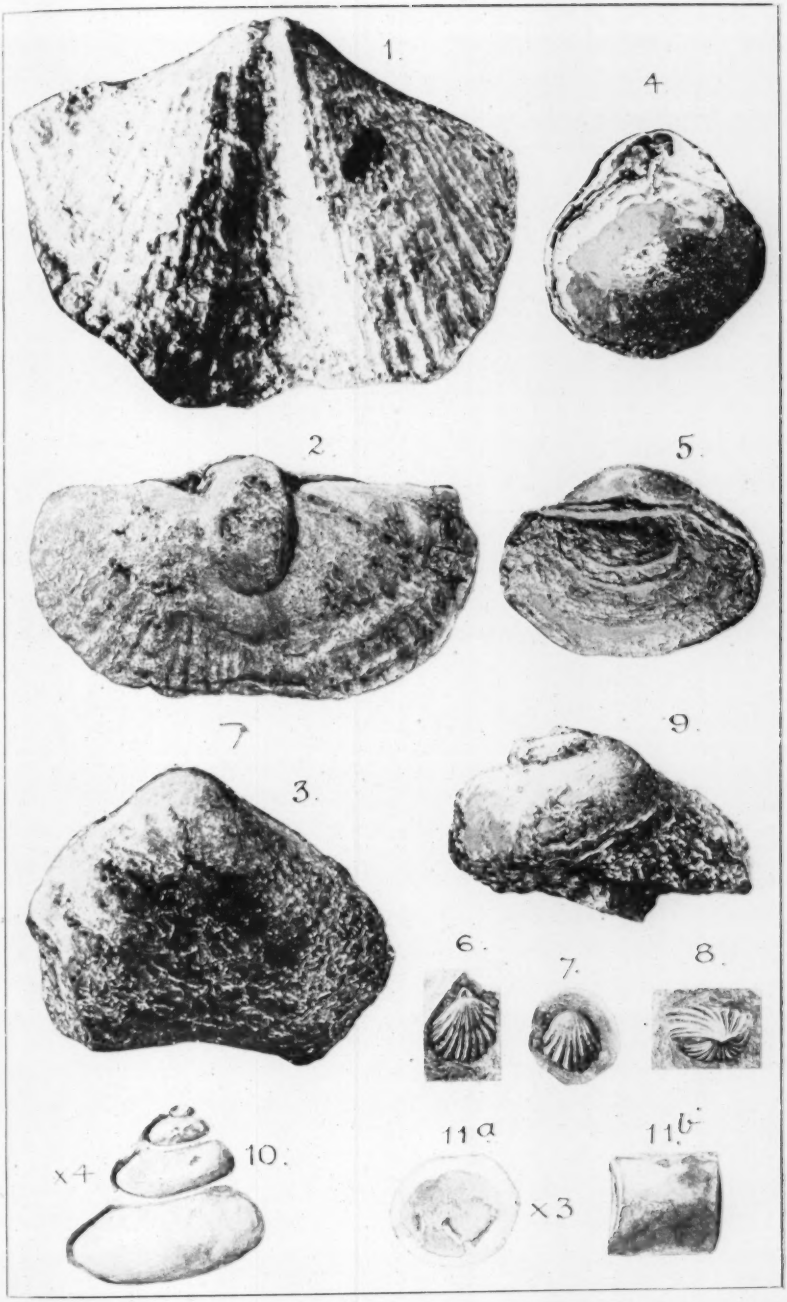
By Professor Grenville A. J. Cole, M.R.I.A., F.G.S., Royal College of Science, Dublin.

MR. G. W. BULMAN, in an essay on "Chalk Flints and the Age of the Earth",[1] states that Professor Owen regarded the layers of flint in chalk as "the remains of *successive* crops of sponges which grew again and again according to *some periodic law*". Mr. Bulman then observes that the only periods affecting rock-formation are annual, and he suggests that sponge-growth might be rapid during the summer months and that free-swimming reproductive spores might be liberated towards winter, the old sponges then dying off. This implies that the water at the depths in which the sponges lived in our Cretaceous seas was responsive to climatic change, and that the sponges were equally responsive. The suggestion breaks down, however, on another ground, when its author points out that it demands the deposition of 3 or 4 feet of chalk in a year, so that the whole of the English strata above the Albian might have accumulated in about four centuries. Mr. Bulman thereupon remains hesitant and enquiring.

In the extensive literature on flint-formation, there are probably many suggestions to account for rhythmic deposition. The matter appears, however, to be generally passed over in our textbooks. Sir C. Lyell's reference[2] to changes in marine currents, "favouring at one time a supply in the same area of siliceous, and at another of calcareous matter in excess, giving rise in the one case to a preponderance of Globigerinæ, and in the other of Diatomaceæ," seems

[1] *Science Progress*, No. 41, p. 154, July, 1916.

[2] *The Students' Elements of Geology*, p. 265 : 1871.



MAITAI BRACHIOPODS: GASTEROPODS, ETC.

a very casual way of dealing with the difficulties of the problem. G. C. Wallich[1] in 1879 anticipated Mr. Bulman's suggestion of the periodic destruction of sponge life; but his hypothesis allows of a prolonged time-interval between the formation of successive layers. His paper is not systematic and does not provide easy reading; but the following argument may be picked out from it and pieced together. Ordinary Globigerina-ooze contains but little silica, like the beds of chalk between the flint-zones; oceanic dredgings, however, show larger amounts of silica, because they represent only the superficial layer of the deep-sea ooze. This layer contains a large amount of protoplasm floated up from the foraminifera, including Globigerinæ, that multiply on the sea-floor. Sponges flourish in this layer and add the silica of their spicules to it; but a great addition of silica is made by the raining down of radiolarian skeletons from surface-waters. The radiolaria live only at the surface, and their remains are caught in the protoplasmic layer, which thus becomes more and more highly charged with silica. The protoplasmic masses[2] "will become, if not supersaturated with silica, at all events so highly charged with it in a now colloid state more and more closely approaching coagulation, as eventually to asphyxiate—so to speak—the very organisms which have produced them".

Owing, no doubt, to the paucity of thin sections of flint at the date at which he wrote, Wallich shows no appreciation of the fact that the silica of flints replaces calcareous organisms and that a flint-zone may prove to be a pseudomorph of a consolidating bed and not a record of a differentiated layer on its surface. In his reply to the discussion (p. 92), he somewhat vitiates his previous argument by introducing a new point, the attraction by sponges of colloidal silica "which existed at the surface of the mud". The paper, however, is clearly an attempt to meet the question of rhythmic deposition. In recent years, however, zonal crystallization has become realized through a number of attractive experiments, notably those of R. E. Liesegang, and a new field of thought has opened in regard to our familiar flints.

Mr. Bulman,[3] after laying stress upon the annual repetition of sponge-deposits, quotes some correspondence with myself in regard to Liesegang's work, and urges that the prevalence of sponges along particular horizons would in any case be necessary to account for the localization of the silica. He concludes, "I make these remarks with the reservation that there *may be* in Liesegang's work, and in Professor Cole's suggestion, details of which I am not aware, and which might render them a more complete explanation of the *lines of flint* than they appear to be."

Since Liesegang's *Geologische Diffusionen* (Dresden, 1913) is not widely accessible in our Islands, it may be well to mention how the question of flint-horizons is introduced in that highly suggestive and stimulating work.

One of the fundamental propositions governing the deposition of

[1] "A Contribution to the Physical History of the Cretaceous Flints": Quart. Journ. Geol. Soc. London, vol. xxxvi, p. 68: 1880.

[2] Op. cit., p. 82.

[3] Op. cit., *Science Progress*, No. 41, p. 156.

concretionary layers is the fact that a crystal growing in a solution is surrounded by a zone of less than average concentration. The crystal-growth impoverishes the solution round about it. If new material is diffusing into the solution, the impoverished zone becomes again enriched; additions are made to the crystal, and a new unsaturated zone is formed around it.

Where a jelly that has absorbed ammonium bichromate is used as a medium for the diffusion of a solution of silver nitrate, silver chromate is formed. At a certain concentration Ostwald's metastable boundary is attained, and crystallization of the silver chromate occurs, even if there are no nuclei to serve as centres of deposition. Each crystal thus formed is surrounded by an impoverished zone; but the arrival of fresh material again leads to enrichment, and the crystals grow until they form a band within the jelly at the surface where the necessary concentration is produced.

The silver chromate in this experiment arises from reaction with material on the far side of the band, and the distance through which such material moves to reach the crystalline nuclei is limited. An impoverished layer thus arises beyond that of deposition, and the silver nitrate diffusing through the layer of deposition has to progress for some distance before the metastable boundary is again attained. Successive zones are thus built up, with intervals which represent regions of weaker concentration of silver chromate.

As we follow out Liesegang's application of these phenomena to the explanation of zonal structures in agates, in concretions, and in massive rocks, we come with delight upon his brief but illuminating reference (p. 126) to the rhythmic layers of flint in limestone. He pictures a solution of silica or of a silicate spreading through a fairly uniform sediment. Or, in the case of the chalk, the silica may have been at first distributed with approximate uniformity, and then became affected by a progressive "one-sided" precipitation. It is pointed out that drying of the rock, due to elevation, may play its part together with the processes of diffusion.

We may venture to expand this conception in relation to the familiar flint-layers in the chalk. Layer-structure may be reasonably expected in a rock containing concretions, if a solution has moved through the mass from above or from below, or from one side to the other. The movement, in a drying sediment, may be upwards; or the solvent water may drain downwards when the mass is uplifted above the sea. Since the consolidation of the rock usually precedes folding and fracturing processes, it must be held to take place in geological time with some rapidity. Mountain-building processes, as we know, may overtake those of consolidation, and firm rock-masses may be forced into yielding sands and muds of younger age. But the chances are in favour of the occurrence of concretionary deposition while the sediment remains practically undisturbed. The concretions will develop along planes of bedding, because the solution to which they are due has moved perpendicularly to these planes.

This theory is directly opposed to that which many of us have enunciated in our teaching work, when we regarded the concretions as formed along the bedding-planes because these planes provided the

easiest direction of movement for permeating waters. The geological importance of the phenomena of diffusion was set before us by H. J. Johnston-Lavis[1] as far back as 1894, and the rhythmic deposition of silicates in limestone was described by him in association with J. W. Gregory[2] in the same year. These observations have of late received full recognition, and may well prepare us to regard concretionary zones in rocks as lying perpendicular to the direction of movement of solutions.

Cracks may arise in which the materials that elsewhere form concretions may become deposited as the solution concentrates through evaporation; but the main surfaces of deposition are likely to be parallel with the bedding-planes of the sediment in which the concretionary growth occurs.[3]

In sandstones concretions usually imply a mere cementing process, or the local chemical replacement of a material already present as a cement. Cases are now known to us where iron-ores form pseudomorphs of quartz-grains; but the typical examples of concretionary growth by pseudomorphic substitution occur in limestones. Here, of course, there must be a diffusion in two directions; the calcium carbonate must pass out while something is being precipitated in its place. In the case of flints, it has often been supposed that layers more rich in the siliceous spicules of sponges or radiolarians attracted additional silica derived from the solution of similar skeletons in other portions of the rock. While it seemed improbable that the lumps of flint which replace the limestone around casts of siliceous skeletons, or which, in other cases, include mere scattered spicules, owed the whole of their silica to the nucleus around which they grew, it was thought that abundant nuclei were requisite. On the hypothesis of rhythmic deposition, however, the difficulty raised by Dr. Wallich and Mr. Bulman as to a periodic abundance of sponges disappears.

The residual skeletons and spicules in a zone of rhythmic deposition may have acted as nuclei and may thus have aided flint-formation; but for the most part they are preserved merely as casts, like those in the adjoining parts of the chalk that are devoid of flints. A very general solution of the hard parts of diatoms, radiolarians, and siliceous sponges appears to have taken place in the body of the chalk, and the traces of sponges within the flints represent so much material added to the invading solution, until, by exchange with calcium carbonate, silica began to be deposited.

We may note that Mr. Bulman's suggestion that animal matter

[1] "The Causes of Variation in the Composition of Igneous Rocks": *Natural Science*, vol. iv, p. 139: 1894.

[2] "Eozoönal Structure of the Ejected Blocks of Monte Somma," Sci. Trans. R. Dublin Soc., vol. v, p. 264: 1894.

[3] The concentric rings of flint in the chalk of Cromer, described by Clement Reid on p. 4 of *The Geology of the Country around Cromer* (Mem. Geol. Surv.: 1882), seem a case of diffusion of silica outwards from certain centres in a stratum about a foot in thickness. One of these rings has a longer diameter of 15 feet; others are perfect circles 9 feet in diameter. The two concentric circles figured in the memoir certainly suggest rhythmic deposition. It would be interesting to know what physical character of the beds above and below has prevented the rings from developing into spherical shells.

may start the segregation is hardly sustained by the examples that he brings forward. The "tests of sea-urchins and bivalve shells" are not very often "converted into flint". Casts of their interiors are common enough, and flint often encloses the calcareous tests. The infilling of calcareous ooze has become silicified, like the chalk surrounding the remains. The test, especially when formed of calcite, has resisted pseudomorphism.

There is something inspiring in the conception of a thousand feet of chalk, with an area of some thousands of square miles, acting as a medium for waters which rearrange the silica left by organisms throughout its mass. It remains to be seen if field-observations raise any serious objections to this view. If we could find limestones contorted at so early a stage that the zonal silicification set in at a later date, the zones of flint should be independent of the planes of stratification.[1] But flints seem, as I have previously remarked, to belong to the first stages of consolidation, when the waters are being drawn up or sink down vertically through the mass. These waters group the silica as they diffuse, and they emerge or drain off elsewhere in the form of calcareous springs.

Though flint in other limestones is often spoken of as chert, our considerations must be by no means limited to the siliceous nodules in the Chalk. Reversing the opinions that we formerly held, we may see in the rhythmic deposition of flint an indication that the silica was originally evenly distributed in the mass. When layers of varying texture and mineral composition are present, they check continuous diffusion. The more uniform conditions in the chalk of Upper Cretaceous age have no doubt given us a classic example; but nodular layers, and even regularly surfaced beds of flint, are known to most workers in the Carboniferous Limestone. A fine instance occurs in the steeply dipping strata in a quarry at Ballintemple, east of the city of Cork. The Portland Beds of the south of England, and the white Cainozoic limestones of the Paris Basin, also furnish examples in easily accessible lands.

IV.—Geology at the Seat of War.[2]

By Aubrey Strahan, Sc.D. (Camb.), Hon. LL.D. Toronto, F.R.S., V.P.G.S.

At a time when the resources of every branch of science are being devoted to the furtherance of the War, it is not inappropriate to consider in what way geological research is being turned to account. At first sight it might appear that the work of the stratigraphical geologist, the palæontologist, or the petrographer might be of domestic and academic interest, but would be unlikely to influence the course of a worldwide war. Such researches have received a respectful

[1] The only reference with which I am acquainted as to the relation of flint-zones to earth-movement is the remark by W. Hudleston in the discussion on Wallich's paper that flints are absent from 'flat' beds of Coral Rag at North Grimston, but are present where the beds are bent (Quart. Journ. Geol. Soc. London, vol. xxxvi, p. 92). This interesting observation deserves, and may have received, further investigation.

[2] Presidential Address to the Vesey Club, December 12, 1916 (Abstract).

toleration in this country, but have been regarded as a luxury, to be abandoned first among luxuries in time of stress. I venture to hope, however, that it will not be so necessary in the future as it has been in the past to expend energy in urging the claims of science. In the foundation of the Imperial Trust for Scientific Research we may recognize that at least one good result has arisen from the calamity of war.

The Germans have been active in their application of geology at the Front, but that they have been more active than ourselves must not be assumed from the fact that I speak more freely of their proceedings than of our own. The amount of German literature which has reached me since the outbreak of the War is limited, but it suffices to show that a number of treatises on War Geology has been published, and from one of these I extract some significant passages. One author, writing in December, 1915, remarks that first and foremost they (the Germans) have really begun, in different parts of the Front, to make geologists a part of the Army organization. A staff of geologists has been created and placed under the direction of a Professor of the University of Greifswald for one of the divisions of the Western Front, and an extension of duties arranged for when their present task is finished. Among the subjects mentioned as requiring geological advice are the laying of field railways, the provision of water in co-operation with bacteriologists, the examination of marsh-lands, the finding of road-metal, and the guarding against landslides, which may be brought about by gunfire. Hints are given, too, that much greater use has been made of geological maps for military purposes than can be made known now. In fact, I gather from this author, who is himself a professor of palæontology, that a sufficient and intelligent use of geologists would go far to win the War. He admits, however, that an individual geologist may not be infallible, and he acknowledges that in attack or retreat the first line cannot wait for the geologist's advice. He proceeds to recommend that full advantage should be taken now of examining the innumerable artificial openings which have been made, and gaining such a knowledge of the ground of our neighbours as may be desirable for military purposes. "For," he continues, "the peace will not be an everlasting peace. Who can hope for that? We, whose country has so often been invaded, must therefore prepare to defend ourselves, and as the new battles may very likely be fought on the ground on which our armies are now fighting, our descendants would be justified in reproaching us if we were so short-sighted as not to avail ourselves of the present favourable opportunity of examining the geological character of the field of battle." I invite your attention to the fact that preparation for another war is suggested while the present war is at its height, and that protection against further invasion of Germany is to be obtained by studying the geology of the territories of her neighbours.

In connexion with the operations on the Western Front a comparison of the geology with that of the South of England acquires a special interest. The severance of England from the Continent is, geologically speaking, a recent geographical incident. That the

chalk escarpments of the North and South Downs are continued in the chalk escarpments which overlook Boulogne is obvious, and that the subdivisions of the Tertiary strata with which we are familiar in the London and Hampshire Basins are recognizable in the North of France and in Belgium is well known. Not only so, but the scenery characteristic of each formation is reproduced with fidelity.

In one respect only the Continental deposits differ materially from those of our home counties. Over wide tracts there has been distributed, up hill and down dale, a fine yellow loam, the *limon* of Belgian geologists, which is doubtfully, if at all, recognizable in England. The thickness varies from 100 feet in the valleys to a mere trace on the flanks of the higher hills, where it shades into hill-talus, but the material is generally spread as a mantle over the country regardless of elevation. This is the deposit with which our men are generally in contact in trenches and the smaller dug-outs, and which is in evidence on the clothes of those returning from the Front.

Much has been written on the origin of the *limon*. It has not the character of a stratified subaqueous deposit, and its fossils include no marine and but few freshwater shells. Land shells, however, are embedded in it, with the bones of various herbivorous and carnivorous mammals. Judged by all these characters, its uniformity of grain, its disregard of level, and its fossil contents, it has been attributed in the main to subaerial agencies. It is in fact a dust, distributed by the wind and retained wherever it settles on ground thickly clothed with vegetation. Like the loess, with which it has many characters in common, it appears to have been formed in countries which suffer from extreme alternations of dry and wet seasons.

In dry weather the *limon* readily returns to a condition of dust; in wet weather it forms a mud unlimited in quantity and obstructiveness. But as a material in which trenches and dug-outs can be excavated with the minimum of labour it seems to have found some use. Under the *limon* and for the most part visible only by means of wells or boreholes, lie the Tertiary and Cretaceous formations.

The southern margin of the Tertiary tract, which includes the London and the Belgian Basins, runs near Basingstoke, Guildford, and Canterbury to the coast near Deal. It strikes the French coast south of Calais, and passes thence by Béthune, Mons, Namur, and Liège. As far as Béthune the margin lies within the lines of the Allies as at present situated, but thence southwards it passes into ground occupied by the enemy.

Along parts of the margin the strata, both the Tertiary beds and the Chalk below them, are tilted up at a high angle, as for example near Guildford, and in such a case the Chalk projects in a ridge, typically illustrated in the Hogs Back. But on the Continent the Chalk emerges at a gentle angle, and the passage from rolling Chalk downs to low undulating plains of Tertiary beds is gradual. Indeed, outlying patches of Tertiary beds, from a few acres to a few square miles in area, are scattered abundantly over the higher parts of the downs. Geologically this tract is comparable to many parts of Hertfordshire, Buckinghamshire, Berkshire, Surrey, and Kent, and

the close correspondence of the strata in detail gives a peculiar interest to a study of these parts of England at the present time.

In the London Basin we recognize three groups in the lower Tertiaries, and in the Hampshire Basin the same three groups with other higher Tertiary strata which have been removed from the London area by denudation. The lowest group, resting directly upon the Chalk, is known as the Reading Beds and Thanet Sands with pebble beds. The thickness of the group amounts to 100 feet in places. At its base lies a layer of unworn chalk-flints coated with a green silicate of iron, and interbedded in the sands are clays, often of a vivid red colour.

These characters are reproduced in the *Landenien* of Belgium. The interbedded clay is known as the *Argile de Louvil*.

The Reading Beds pass below the London Clay, and under suitable circumstances the water in them is held down under pressure by that impervious covering. In such cases, when a hole is bored through the clay, the water rises from the sand and overflows at the surface. This used to be the case years ago in parts of London, and well-borers sometimes found themselves in unexpected possession of an uncontrollable fountain which flooded their own and their neighbours' premises. On the Continent an artesian supply is still available in suitable conditions within the margin of the Tertiary basin. The water, however, is potable only near the margin; in the inner parts of the basin, far away from the outer edge, it is too heavily loaded with mineral matter to be usable.

The London Clay, which comes next above the Thanet Sand, has a thickness of 400–450 feet. It corresponds in character, thickness, and fossils to the *Argile de Flandres*, or the *Yprésien* of Belgian geologists, except that in Belgium it consists in the upper part of alternating bands of sand and clay. London Clay has its uses. Almost the whole of the system of tube-railways under London has been constructed in this watertight material. The earlier underground railways, the sewers, and other works were situated nearer the surface, and encountered large quantities of water in the superficial gravels; the tubes were protected by clay above and below, except in a few exceptional localities.

The Bagshot Sands come next above the London Clay. These attain a thickness of approximately 1,000 feet in Hampshire, but in the London Basin have been for the most part denuded away. Parts of them, however, still remain near Aldershot, Bagshot, and Ascot and on the tops of Highgate and Hampstead Hills. Wherever they exist they make their presence apparent by a characteristic scenery of heath or pine forest. In Belgium they are represented by the *Paniselien* and *Bruxellien* Sands, and there also they produce a type of country which is in strong contrast with that produced by the Yprésien Clay. The conspicuous hill on which Cassel stands is composed in the main of Paniselien Sand, though it includes some later formations on its summit. Eastwards, as the Belgian Tertiary basin is approached, the Paniselien Sand comes on in greater force. It forms the bold range of hills which surround Ypres on its southern and eastern sides, and which includes the site of the famous Hill 60.

The Paniselien and Bruxellien Sands absorb a large proportion of the rain that falls upon them, and give out the water as springs at their base, where they rest upon impervious clays or along any interbedded clay-band. Bailleul draws, or used to draw, a part of its supply from a spring of this character in the side of Mount Noir, one of the hills south of Ypres. Ypres was supplied by similar springs at Dickebusch and Zillebeck, but the gathering-ground of the springs includes the scene of some of the most murderous fighting of the war, and it may well be questioned whether water drawn from such an area can be usable. In other parts of Belgium a system, which is rarely seen in Britain, of driving tunnels under the larger tracts of such sands and collecting the water by branching galleries, has been adopted. Brussels is partly supplied in this way.

The Chalk of the South-East of England includes three subdivisions of more or less distinctive lithological characters. The Upper Chalk is a massive type of chalk set with nodules or rows of nodules of flint. This subdivision ranges to upwards of 600 feet in thickness and forms the upper and bolder part of the chalk escarpments. The Middle Chalk is a thick-bedded chalk generally devoid of flints, and the Lower Chalk includes much chalk marl. The Upper Chalk is the source of water of the majority of chalk wells. The Lower Chalk, on the other hand, though it may hold much water, yields it but slowly on account of its marly and almost impervious character. For this reason the Lower Chalk has been much discussed as a suitable stratum in which to drive a tunnel from Dover to Calais. In fact, the small part of the tunnel which has been driven is situated in this subdivision.

In the North of France these subdivisions of the Chalk present much the same characters as in the South-East of England, but there extends from near Calais towards Mons an underground bar, which clearly existed in the Cretaceous sea as a ridge or at any rate an obstruction to the free circulation of currents. The Upper Chalk, though it crosses the bar, changes its character. The whole formation assumes a marly character under Flanders, and loses its value as a reliable source of good water. Herein lies the difficulty of finding water supplies in Eastern and Western Flanders. The Landenien water is often not potable, and the Chalk yields none. The Palæozoic rocks beneath yield salt water, if any, and the uplands of Paniselien Sand are too limited in area to give a sufficient supply by gallery. Under these circumstances recourse has been had to rain and canal water, rendered harmless, as believed, by chemical treatment and filtration. So keenly was the lack of good water felt that a project was on foot before the War to supply the towns of Low Belgium from a source in the Ardennes. The supply had been carried to Brussels, and its further distribution was in progress when the War broke out.

Chalk forms one of the most suitable rocks for dug-outs, provided that the excavations are not carried below the level of the underground water. It is not difficult to excavate, and yet firm enough to stand fairly well. The extensive and elaborate system of underground dwellings recently captured by our troops have been excavated in the Chalk.

For obvious reasons it would be unwise to describe in detail the problems which have arisen for solution at the Front, but it may be legitimate to remind you that tunnels, unlike wells, should be so designed as to keep clear of water, and that the best way of effecting this object is to keep the operations within the limits of a watertight formation, as was done in the case of the tube-railways. An exhaustive study of the thicknesses and inclinations of the strata, and especially of the faults or folds by which they are affected, is required for the purpose. The necessary observations are not easy to make, for the calm reflection required for the solution of a geological problem is apt to be interrupted by the attentions of the enemy. Operations are of necessity hurried and hazardous. It is well also to endeavour to realize the conditions under which our men are working in the tunnels. There is no branch of the Services, whether on the sea or under it, on the ground or in the air, in which pluck and endurance have not been manifested to a degree which would have been scarcely credible two or three years ago. No less are these qualities called for in the men who are working in the bowels of the earth, with the ever-present danger of being forestalled by the enemy and of being buried alive with no possibility of rescue.

The Secondary and Tertiary formations rest upon an undulating plane cut in the Palæozoic rocks, conveniently known as the Palæozoic floor. These ancient rocks have been thrown in the course of geological ages into the most complicated structures. Not only are they folded, but along certain belts of country they have been inverted and their newer members thrust bodily over their older members. The plane therefore cuts across rocks of many ages, ranging from Coal-measures to Cambrian or earlier. In the locating of Coal-measures among these older rocks, under the blanket of Secondary and Tertiary strata, lies the problem of extending the coal resources of the country.

The first step towards accomplishing this in the South of England was taken in Kent, where the existence of Coal-measures was anticipated on geological reckoning many years ago and proved in 1886. It was argued that the Axis of Artois, a belt characterized by intense folding and overthrusting from the south, which ranges past Liège, towards Douai and thence to the coast near Calais, must continue through the South of England, and that there might be coalfields entangled in it in England as on the Continent.

The numerous borings put down in Kent since 1886 have had the result of proving that the Coal-measures there lie in a trough in the Carboniferous Limestone, the axis of which ranges in a north-westerly direction. The dips observable in the cores are usually gentle, and there is nothing to suggest faulting or folding such as characterize the coalfields situated on the Axis of Artois.

It therefore is still a matter of doubt whether the Kent Coalfield is situated on that axis, and not to the north of it, and whether it does not compare in this respect with the coalfield of La Campine. This field was discovered in 1901, and twelve or more shafts were being sunk through the Tertiary beds and the Chalk into the Coal-measures when the War broke out. By some Continental geologists

it is thought likely to be continuous with the Yorkshire Coalfield, by others with the Kent Coalfield, but attempts to follow it in a northerly direction have so far been defeated by the great thickness of Tertiary sands near Antwerp. Apart from the highly speculative question of its extension in either of the directions named, it seems to be comparable to the Kent Coalfield in its relation to the great belt of folding along which the other Belgian coalfields are situated.

V.—Note on *Plectrodus*, the Jaw of an Upper Silurian Fish.

By Arthur Smith Woodward, LL.D., F.R.S.

When fish-remains were first discovered in the Ludlow bone-bed and other horizons of the Upper Silurian series, some of the fragments were regarded as toothed jaws by Agassiz, who described them under the names of *Plectrodus mirabilis*, *P. pleiopristis*, and *Sclerodus pustuliferus*.[1] The same fossils were afterwards considered to be of Crustacean origin by M'Coy,[2] but definitely proved to be fish-remains by the microscopical examination of Harley, who pointed out that while they could not be teeth or jaws, they appeared to him to be "the posterior spines of the cephalic plate of some Cephalaspidian fish".[3] The latter view was adopted by Lankester, who treated the specimens as parts of the cornua of a small Cephalaspidian head-shield which he named *Eukeraspis pustuliferus*.[4]

Egerton[5] also described similar fossils as jaws, and among these was one specimen from the Downton Sandstone (Brit. Mus. No. 45969), which I studied some years later and considered to resemble a fish-jaw rather than a cornu of *Eukeraspis*.[6] In 1893 Rohon[7] made a microscopical examination of several fragments both from the Ludlow bone-bed and from the well-known Upper Silurian limestone in the Isle of Oesel (Baltic Sea), and concluded that while some of the specimens ascribed to *Plectrodus* and *Sclerodus* were Cephalaspidian, others were certainly not of this nature. He described the latter as exhibiting "denticles and tubercles of vasodentine, and the base not formed of true bony tissue but of a bone-like substance". In 1898 I found in the Museum of Neuchâtel three of the original specimens from the Ludlow bone-bed which were described by Agassiz (labelled "Rev. Wm. Evans, 1836"), and two of these (figured in *Siluria*, pl. iv, figs. 15, 25) appeared to me distinctly jaw-like. In 1910

[1] L. Agassiz, in Murchison's *Siluria*, 1839, p. 606, pl. iv, figs. 14–32, 60–2.

[2] *Pterygotus pustuliferus*, F. M'Coy, Quart. Journ. Geol. Soc., vol. ix, p. 14, 1853.

[3] J. Harley, "On the Ludlow Bone-Bed and its Crustacean Remains": Quart. Journ. Geol. Soc., vol. xvii, p. 544, 1861.

[4] E. Ray Lankester, *Fishes of the Old Red Sandstone*, pt. i (Pal. Soc., 1870), p. 58, pl. xiii, figs. 9–14.

[5] P. M. G. Egerton, "On some Fish-remains from the Neighbourhood of Ludlow": Quart. Journ. Geol. Soc., vol. xiii, p. 288, pl. x, figs. 2–4, 1857.

[6] A. S. Woodward, *Catalogue of Fossil Fishes in the British Museum*, pt. ii, 1891, p. 195.

[7] J. V. Rohon, "Die Obersilurischen Fische von Oesel": Mém. Acad. Imp. Sci. St. Pétersbourg [7], vol. xli, No. 5, p. 95, 1893.

Priem[1] described and discussed similar fossils from the Upper Silurian of S. Felix, Laundos, Portugal, and decided that *Plectrodus*-proper at least was a jaw, although *Selerodus pustuliferus* was undoubtedly part of the cornu of the Cephalaspidian *Eukeraspis*.

Later studies have convinced me that the true *Plectrodus* (as typified by *P. mirabilis*) is indeed a jaw, and that it most closely agrees with the toothed jaws of the Lower Devonian Acanthodian *Ischnacanthus*.[2] I am, therefore, much indebted to Mr. W. Wickham King, F.G.S., for the opportunity of examining the microscopical structure of an unusually large specimen, probably of a new species, which he has recently found in the Downtonian of Baggeridge, S. Staffordshire. The hard base to which the teeth are affixed proves to consist of almost structureless translucent calcified tissue in which there are occasional streams of elongated cellular spaces, irregular in shape, and sometimes with traces of ramifying canaliculi. It thus agrees exactly with the corresponding tissue in *Ischnacanthus*.

In this connexion it is interesting to add that both in Oesel and in Portugal separate whorls of teeth such as occur in front of the lower jaw of *Ischnacanthus*,[3] have been found in the same rocks as *Plectrodus*.[4] On the other hand, no typical dermal tubercles of Acanthodian fishes have hitherto been recognized in any Upper Silurian formation, and the occurrence of Acanthodian fin-spines is uncertain. We may, therefore, conclude that the toothed Acanthodians of the Lower Devonian were preceded in the Silurian by fishes with similar jaws, but the precise nature of these earlier fishes still remains to be determined.

VI.—On the Geology of the District from Cil-y-Coed to the St. Annes–Llanllyfni Ridge (Carnarvonshire).[5]

By E. Wynne Hughes, M.Sc., F.G.S.

(*Concluded from January Number, p. 25.*)

B. Pre-Cambrian, Rhyolitic Series.—(i) At the south-west end of the Craig-y-Dinas mass we find exposed a rock similar in every respect macroscopically to that which is found at Cil-y-Coed. Unfortunately it cannot be followed far, as the land is completely under drift, the top of Craig-y-Dinas itself being capped by a thick layer of drift.

[1] F. Priem, "Sur des Poissons et autres Fossiles du Silurien supérieur du Portugal": Communic. Serv. Géol. Portugal, vol. viii, p. 3, pl. i, figs. 7–10, 1910.

[2] A. S. Woodward, *Catalogue of Fossil Fishes in the British Museum*, pt. ii, 1891, p. 20. B. Dean, "Notes on Acanthodian Sharks": Amer. Journ. Anat., vol. vii, p. 209, figs. 1–10, 1907. E. S. Goodrich, in Lankester's *Treatise on Zoology*, pt. ix, 1909, p. 190, fig. 160.

[3] A. S. Woodward, Presidential Address, Quart. Journ. Geol. Soc., vol. lxxi, p. lxvi, 1915.

[4] *Campylodus sigmoides*, J. V. Rohon, loc. cit., p. 52, pl. i, fig. 25, 1893; *C.*(?) *delgadoi*, F. Priem, loc. cit., p. 5, pl. i, figs. 11–15, 1910.

[5] Plates I and II and two maps, which illustrate this paper, will be found with the first part in the January Number, pp. 13 and 15.

(ii) Five hundred yards almost due north of Craig-y-Dinas, near the farm of Eithinog-Wen, a small amount of solid rock is present. A careful examination shows that this rock again compares closely with the rhyolitic series of Cil-y-Coed. Porphyritic quartz and pink felspars can be seen even in hand specimens. The groundmass is fine-grained, compact, and felsitic, differing only from the Cil-y-Coed rhyolites in its pink coloration. Beyond Eithinog-Wen a close search of the slope of the ridge, that runs in a northerly direction here, disclosed no further exposures. The large amount of debris, however, that is present everywhere at the foot of the ridge suggests the presence of the rhyolitic rock.

(iii) At Bryn-mawr, 1,500 yards to the N.N.E. of Craig-y-Dinas and 1,000 yards from Eithinog-Wen, several rock masses are exposed. The distance between the first and last of these exposures is fully 600 yards. They all occur near the top of the ridge, and are undoubtedly portions of the same mass. The line of outcrop, if continued in a southerly direction, would pass through the exposures at Eithinog-Wen and Craig-y-Dinas. The largest of these exposures is the quarry near the roadway close to Glyn-Llifon Park. It is at present being worked for road-metal. In some cultivated land on the north side of the road further exposures of this rock are also to be seen.

In hand specimens all the rocks compare closely with one another, showing porphyritic crystals of quartz and felspar in a fine-grained and compact groundmass. Several microscopic sections were examined, and they bring out the close resemblance between these rocks and the rhyolitic series at Cil-y-Coed. They show the presence of porphyritic crystals of quartz and both orthoclase and plagioclase. The quartz crystals are much more numerous than the felspars, but many of the latter still show multiple twinning. The groundmass is cryptocrystalline, with patches sometimes coarser and sometimes finer-grained, and it frequently shows good fluxion structure. (Pl. I, Fig. 1.)

We have here, then, a rock very similar, both macroscopically and microscopically, to the rhyolitic rocks of Cil-y-Coed.

C. Summary of the Succession.—We have, then, in the area between Pentwr and Bryn-mawr:—(i) Cambrian: (*a*) green slates at Ysgubor-Wen, (*b*) green grit band at Pentwr, (*c*) purple slates at Llech-y-dwr, (*d*) fine and coarse grits at Craig-y-Dinas, and also (*e*) a much cleaved conglomerate at Craig-y-Dinas, all with a dip of 50° S.S.E., lying upon (ii) Pre-Cambrian, (*f*) rhyolites and tuffs exposed at Craig-y-Dinas, Eithinog-Wen, and Bryn-mawr.

D. Relation to the Surrounding Areas.—(i) South-east of Pentwr we have already noted the occurrence of Ordovician slates on Y Foel. These can be traced through Tai-lon to Pen-y-garreg and beyond.

(ii) Unfortunately the Cambrian slates and grits cannot be similarly traced to Cil-y-Coed. The strike of the beds in the two localities suggests the presence of a fault in the intervening country, but no other evidence of it could be obtained, though this is the direction of the fault marked on the Survey map (1850).

(iii) To the west and north-west the country is flat and low-lying. No solid rock was found anywhere in this direction.

(iv) The most northerly exposure of the Pre-Cambrian rhyolite series is within 400 yards of the boundary assigned to the St. Annes–Llanllyfni ridge in the Geological Survey map (1850). The nearest locality on this ridge where solid rock is exposed is at Parc Pant-dy, 800 yards due east of Pen-y-groes and a mile and a half east of Bryn-mawr. Referring to the rocks at this end of the ridge, the Survey memoir states :—

"Further south the conglomerate forms the highest points of Moel Tryfan and Mynydd Cilgwyn, where it is partly metamorphosed into a sort of talcose schist and conglomerate. Beyond this it has been either completely obliterated, or, curving round to the east near the crest of the hill, it is cut off by a fault which throws the superincumbent purple slate directly against the porphyry. It is seen that the grits and lower conglomerates disappear at Mynydd Cilgwyn, but the purple slates that are interstratified with these follow an unbroken line to the neighbourhood of the turnpike road near Llanllyfni. The general character of the porphyry is that of a felsitic rock with an amorphous grey felspathic base containing small crystals of quartz, which are often somewhat granular, sometimes hexagonal, and sometimes they seem to be four-sided prisms.

". . . It also contains small distinct crystals of glassy felspar. The base of the conglomerate is highly felspathic and sometimes crystalline, enclosing pebbles of felspathic trap, quartz, quartz rock, purple and black slate, and jasper. The whole mass is altered, and it is easy to note first: the disappearance of the granular structure in the conglomerate or sandy matrix and its gradual assumption of a porphyritic character, with small crystals of felspar embedded, while the enclosed pebbles still retain their distinctive form; and again, approaching the recognised porphyry the hard outlines of the pebbles in the conglomerate gradually melt away till they become undistinguishable in the general fusion of the rock, and the view that the porphyry is not an intrusive mass is aided by the fact that it is impossible to define any line of demarcation between conglomerate and porphyry."[1]

Evidently, then, we have on the St. Annes–Llanllyfni ridge a succession very similar to that at Craig-y-Dinas and Cil-y-Coed. *In consequence, the south-west portion of the ridge between* Moel Tryfan and the village of Llanllyfni was carefully examined.

3. The St. Annes–Llanllyfni Ridge.

A. Moel Tryfan.—The conglomerate at the top of Moel Tryfan seems outwardly identical with that at Cil-y-Coed. The pebbles are well rounded and of various sizes, though seldom more than 3 inches long. They are mainly of volcanic origin and are enclosed in an argillaceous matrix. There are also quite a number of quartzose pebbles of a type which is of rare occurrence in the conglomerate at Cil-y-Coed and Craig-y-Dinas, and the matrix is distinctly more argillaceous. On the top of Moel Tryfan there are no exposures of the quartz-porphyry or the quartz grit, but not more than 200 yards to the east of the conglomerate we find, at the Alexandra Slate Quarry, a great thickness of purple slate.

From this quarry an adit has been driven east and west right through the mountain. An examination of the rocks in this adit shows that a quartz grit occurs here on the eastern side of the

[1] Mem. Geol. Surv., vol. ii, p. 143, 1866.

conglomerate. Both the conglomerate and the quartz grit dip steeply to the south-east. A further point of interest is the existence of several well-marked faults, running north-east to south-west. These faults have the same direction as the fault between the grits and the Ordovician slates on the south-east side of Cil-y-Coed.

Several thin sections from the conglomerate in the adit were examined; they show that the conglomerate bears a close resemblance to that at Craig-y-Dinas and Cil-y-Coed. Thin sections of the grit from the two localities are also very similar, though perhaps the Moel Tryfan grit approximates more closely to a true quartzite.

The adit shows that the whole mass has undergone great disturbance, there being at least six faults visible in the adit, with the result that the structure is highly complicated. The conglomerate, for instance, is only 12 feet thick in the adit, whereas on the mountain top it has an outcrop fully 120 feet wide. Between the conglomerate and the porphyry at the west end of the adit, is a thickness of fully 200 yards of green slate, grit, gritty slate, and a green chloritic rock. Whether these slates and grits are Lower Cambrian or Pre-Cambrian is a question of some difficulty which I hope to investigate at a future date.

An examination of the adit then shows that—

(*a*) The conglomerate and quartz grit here bear a close resemblance to those at Cil-y-Coed and Craig-y-Dinas.
(*b*) They are in the same relative position.
(*c*) Their dip, although steeper, is in the same direction.
(*d*) As at Craig-y-Dinas, they are overlain by purple slate.
(*e*) The conglomerate in the adit does not lie directly on the quartz-porphyry.
(*f*) The matrix of the conglomerate is more argillaceous than that at Craig-y-Dinas and Cil-y-Coed.

B. Bwlch-y-llyn and Cilgwyn.—The conglomerate was traced in a south-westerly direction. At Bwlch-y-llyn the quartz grit also comes to the surface, and is again lying directly upon the conglomerate on its south-east side. An examination of microscopic sections cut from specimens in this locality again brings out a close resemblance between the grit here and that at Cil-y-Coed and Craig-y-Dinas. Like the latter, the grit at Bwlch-y-llyn ranges from fine to coarse, becoming more quartzitic from north-west to south-east. (Pl. II, Figs. 4, 6.)

From this point on, the conglomerate forms the high ground on Mynydd Cilgwyn, and it persists in a south-westerly direction along the whole length of the mountain. On the south-west slopes of the mountain, however, it disappears in the manner indicated in the Survey memoir. The pebbles in it, on this portion of the ridge, are certainly less numerous, but they are decidedly larger than at Moel Tryfan, and, what is still more interesting, the matrix is distinctly more felspathic. In hand specimens and under the microscope this gritty matrix could hardly be distinguished from the gritty matrix of the conglomerate at Cil-y-Coed. (Pl. II, Figs. 1, 2.)

Owing to the presence of several quarries on the east side of the ridge, the purple slate can easily be traced in a S.S.E. direction from Moel Tryfan to Cilgwyn. At Cilgwyn it is exposed at the

Old Cilgwyn and Veingoch quarries. The former of these two quarries lies only 250 yards away from the conglomerate, but does not expose the grit.

On Mynydd Cilywyn, moreover, the quartz-porphyry is exposed in several places, always to the west of the conglomerate, but the exact line of junction could not be seen. Several microscopic sections of the quartz-porphyry were examined, and here again the resemblance to the rhyolitic rocks of Bryn-mawr and Cil-y-Coed is most marked. The rocks contain porphyritic crystals of quartz and felspar embedded in a cryptocrystalline matrix which grades to microcrystalline in a patchy manner. It will be interesting to record here Bonney's description of microscopic sections from this ridge. He states:—

"The general type is a compact dull felsite with porphyritic crystals of felspar and grains of quartz closely resembling some modern rhyolites. On Moel Gronw angular fragments of a pinkish tint are scattered through the general mass. Again, some parts are crowded with quartz grains, while others are comparatively free of these, and occasionally a spherulitic structure is observed. The rock was probably originally vitreous, and there are abundant fresh examples of the most perfect flow-structure in the rock." [1]

This description compares very closely with that already given of the Cil-y-Coed and Bryn-mawr rhyolitic rocks.

C. Clogwyn Melyn to Caer Engan.—On the southern slopes of Mynydd Cilgwyn the conglomerate stops abruptly. All the lower slopes of the hill on this side are composed of rhyolitic rocks very badly sheared. A careful examination of the area disclosed no exposure of either conglomerate or grit, although a large amount of solid rock is exposed, all of which is massive rhyolite becoming more and more sheared towards the east. As indicated in the Geological Survey Map the rhyolite in this area is brought up against the purple slates. The rhyolite was traced through Parc Pant-dy to the lower roadway going from Pen-y-groes to Talysarn. Here it stops abruptly. But a small area of the rhyolite is exposed again at Caer Engan, 500 yards to the south-east of the nearest exposure in the main mass. In addition, a very narrow band of the conglomerate is found on the south-east side. It is badly crushed and the pebbles almost unrecognizable. The matrix is similar to that at Moel Tryfan, being argillaceous rather than felspathic. The greater portion of the hill, however, is composed of a felsitic rock, which both in hand specimens and in microscopic sections resembles the light variety at Cil-y-Coed; but whatever fluxion structure it may contain is obscured by shearing.

Furthermore, 200 yards to the east of Caer Engan there is a small quarry in purple slates, but there is no exposure of grit in the intervening area.

D. Summary of the Succession.—We have, then, on the St. Annes–Llanllyfni ridge—

(i) Rhyolitic rocks, conglomerate, and quartz grit at Moel Tryfan.
(ii) Conglomerate and quartz grit at Bwlch-y-llyn.
(iii) Rhyolitic rocks and conglomerate at Mynydd Cilgwyn.
(iv) Rhyolitic rocks and conglomerate at Caer Engan.
(v) Purple slates all along the eastern side of the ridge.

[1] Q.J.G.S., vol. xxxv, p. 312, 1879.

IV. Conclusion.

The different formations at all the above localities on the St. Annes–Llanllyfni ridge lie in the same relative position to one another as the purple slates, grits, conglomerate, and rhyolitic series at Craig-y-Dinas, and the grits, conglomerate, and rhyolitic series at Cil-y-Coed. Further, the different formations are each to each lithologically similar. This resemblance is well brought out in Plate II, showing microphotographs of the conglomerate: Fig. 1, from Cil-y-Coed; Fig. 2, from Mynydd Cilgwyn; the fine grit: Fig. 3, from Cil-y-Coed; Fig. 4, from Bwlch-y-llyn; the coarse grit: Fig. 5, from Cil-y-Coed; Fig. 6, from Bwlch-y-llyn.

The evidence seems, therefore, conclusive that the series at Cil-y-Coed and Craig-y-Dinas are of the same age as those of the St. Annes–Llanllyfni ridge. Accepting the view, usually held, that the porphyry on this ridge is pre-Cambrian and that the conglomerate is basal Cambrian, we have—

1. At Cil-y-Coed—Lower Cambrian grits and conglomerate lying on Pre-Cambrian rhyolites and tuffs.
2. At Craig-y-Dinas—Lower Cambrian green and purple slates, grits, and basal conglomerate lying on Pre-Cambrian rhyolites.
3. At Bryn-mawr—Pre-Cambrian rhyolites and tuffs.

Pre-Cambrian Rhyolites and Tuffs.—To sum up, the solid rocks exposed in the area between Cil-y-Coed and the village of Pen-y-groes comprise a volcanic series of rhyolitic type, probably Pre-Cambrian, overlain by a series of conglomerates, grits, and slates of Lower Cambrian age. This sequence represents substantially the succession which obtains in the main portion of the St. Annes–Llanllyfni ridge to the north-east; and it is clear that the solid rocks of the St. Annes–Llanllyfni ridge extend at least 3 miles further south-west than is represented in the Geological Survey Map.

In conclusion, I desire to express my indebtedness to Mr. C. J. Edwards for suggesting the work on Cil-y-Coed and for several photographs, to Dr. Cox for reading through the manuscripts and for various suggestions during the course of the investigation, and to Dr. Gordon for his help in connexion with the microphotographs.

REVIEWS.

1.—The Geography and Geology of West-Central Sinai. By John Ball, Ph.D., D.Sc., F.G.S., A.R.S.M., Mem. Inst. C.E. pp. ix, 219, with two geological maps printed in colour, 22 plates, and 54 text-figures. Cairo: Government Press, 1916. Price 30 P.T.

THIS important work owes its origin to the discovery of ores of manganese and iron in the Sinai Peninsula by the late Mr. Thomas Barron during his reconnaissance survey of a vast area in Western Sinai in the years 1898–9. Prospecting followed, the Sinai Mining Co. was formed to exploit the deposits, and Dr. Ball was deputed by the Director of the Geological Survey of Egypt to

carry out a detailed topographical and geological survey of the area in which the more important deposits occur. He has produced an accurate map of an area of 380 square miles limited by the parallels of 29° 15′ and 28° 56′ 20″ N. lat. and by the meridians of 32° 9′ 35″ and 33° 27′ 30″ E. long. on a scale of 1 : 50,000, on which the distribution of the various geological formations, ranging from the granite and gneiss of pre-Carboniferous age through the Carboniferous, Cretaceous, and Tertiary to the Pleistocene and Recent deposits of alluvium and blown sand, is laid down. The topographical and geological details were recorded simultaneously, and as an illustration of Dr. Ball's skill and neatness as a surveyor it may be mentioned that the maps are based on direct photographic reproductions of the field-sheets. In addition to the general map, the work is illustrated by a larger scale map (1 : 25,000) of the environs of Um Bogma, where the chief mines are situated, a plate of sections, numerous photographs, and a large number of text-figures, including pen-and-ink sketches of the most typical fossils drawn by the author from actual specimens.

After describing the general features of the district, which consist of highly dissected tablelands and assemblages of rugged granitic peaks, with occasional more open areas, the author gives an account of the survey operations, of the methods adopted in laying out the base-line, in determining its geographical position, and in connecting up the triangulation with that of Egypt proper. Then follow chapters dealing with the topographical features—the wadis, the mountains and the plains—and with the geology.

In the centre of the area lies a broad sandy plain at a height of about 500 metres above sea-level, on which the base-line was laid down. This is bounded on the north by the formidable escarpment of Gebel el Tih, the edge of which is from 500 to 600 metres above the plain and extends from east to west in a somewhat sinuous curve. The base of the escarpment is formed of Nubian Sandstone, then follow 200 metres of fossiliferous Cenomanian clays, marls and limestones, which are capped by beds of Turonian limestone. The escarpment forms the southern termination of a deeply dissected plateau which stretches far to the north, and it is a remarkable fact that although the valleys descend rapidly from the edge in that direction, none appears to have been beheaded by the recession of the escarpment. Many points on the edge have been accurately fixed.

South of the central plain is a wild country with only relics of plateau structure, in which many mountains rise to heights of 700 or 800 metres above the sea and one to over 1,000 metres. It consists of the pre-Carboniferous complex of granite and metamorphic rocks, on the planed-down surface of which rest strata of Carboniferous age. The time available did not admit of any attempt to separate the rocks of the complex, which is presumably Archæan. The Carboniferous rocks consist of a lower sandstone (130),[1] a middle limestone with fossils, similar to those occurring in Derbyshire and Yorkshire (40), and an upper sandstone with *Lepidodendron* (130). To the west of the central plain this upper sandstone underlies the Nubian Sandstone,

[1] The figures in parentheses represent thicknesses in metres.

which it closely resembles. This point is one of great interest on account of the discussion which has taken place as to the age of the Nubian Sandstone. In the region we are considering the vast period of time separating the Carboniferous Limestone from the marine Cenomanian clays is represented by 650 metres of sandstone, which are conformable to the rocks below and above, and in which no break can be detected. Dr. Ball separates the lower portion of this series (130) under the name of Upper Carboniferous Sandstone, on account of the occurrence of fossils of the *Lepidodendron* type, from the upper portion (500) to which he restricts the name of Nubian Sandstone. The only traces of fossils found in the upper portion are a piece of silicified wood "similar to that which occurs in the Nubian Sandstone of Egypt", and a thin layer of very impure coal. Owing to the discovery of *Inoceramus* in the Nubian Sandstone of Aswan and the intercalation of the sandstone with the overlying marine Cretaceous in other parts of Egypt this formation is now generally regarded as being of Cretaceous age. Until quite recently no trace of marine fossils of Triassic or Jurassic age has been found either in Egypt or Sinai, but Dr. Ball refers to a discovery of Jurassic deposits in the northern portion of the peninsula, and suggests that part of the Nubian Sandstone may be of the same age. Details of this important discovery do not appear to have been made public.

So far we have been referring to about three-fourths of the area covered by the map. This portion is bounded on the west by a series of important faults following a general direction a little east of south, roughly parallel to and at an average distance of about ten kilometres from the Gulf of Suez. The remaining portion consists principally of Campanian strata, but contains also representatives of the Eocene and Miocene periods. At one point Miocene rocks are faulted against the Lower Carboniferous Sandstone, and the throw is estimated at probably not much less than 2,000 metres. The faulting is regarded by the author as belonging to the close of the Miocene period; but the possibility of its having commenced at an earlier period must not be overlooked.

Campanian strata (300 ?) form a highly dissected hilly country of a dazzling white aspect. Eocene strata appear to rest conformably on the Campanian. They are much thinner than those on the opposite side of the Gulf of Suez and in the Nile Valley. The Miocene rocks occur in detached patches and comprise conglomerates, gritty limestones, clays, and chalky rocks often impossible to distinguish from Eocene or Cretaceous in the absence of fossils. The author sums up his observations on the Miocene deposits in this part of Sinai by saying that "the more easterly portions are characterized by great accumulations of conglomerates and grits, indicating that the old shore ran approximately along the line of the great fault already referred to, while farther to the west there is increasing predominance of limestones, clays, marls, and gypsum, indicating deeper water conditions for certain beds".

The geological history of Egypt during post-Eocene times is of great interest, but it is difficult to correlate the available information. The prolonged hydrocratic movement which lasted during the

Cretaceous and Eocene periods was followed by a geocratic movement in Oligocene times, when the fluvio-marine beds of the Fayum were formed with the remarkable deposits containing mammalian remains at their base. To this succeeded another hydrocratic movement in Miocene times. Miocene deposits occur in northern Egypt, on the borders of the Gulf of Suez, and in the neighbourhood of Ras Mohammed. They occur at different levels and sometimes have the character of beach deposits. Did the earlier Miocene deposits advance over a planed down surface of older rocks? This is suggested by Dr. Ball's work, for it is impossible to avoid the conclusion that the Cretaceous and Eocene deposits once extended over the whole area. Moreover, a small patch of Miocene strata, wedged in between two faults just north of Gebel Sarbut el Gamal, is represented on the map as resting both on Nubian Sandstone and on Cenomanian, whereas Miocene rests on Campanian, without any intervention of Eocene on the mountain itself, of which it forms the summit.

As evidence of the great differences of level at which Miocene rocks occur, it may be pointed out that the boring for oil at Gebel Zeit[1] ended at a depth of about 1,100 metres below sea-level in rocks which are supposed to be of Miocene age, whereas the top of Gebel Sarbut el Gamal is 642 metres above the sea, making a difference of 1,742 metres. How far these differences of level are to be accounted for by deposition at different times while geographical evolution was going on, and how far they are due to movements of elevation and depression affecting large areas or to faults subsequent to deposition, cannot be determined with precision at present, but the last-mentioned cause has certainly played an important part. Basalt sills and dykes occur at many points in the district. They are all referred by the author to the Miocene period.

The ores of manganese and iron (pyrolusite, psilomelane, wad, and hæmatite) occur at the junction of the Carboniferous Limestone and the underlying sandstone in certain places. They form irregular deposits which are only found in the neighbourhood of faults and become thicker and richer as the faults are approached. Where they occur certain dolomitic limestones, containing small amounts of manganese and iron, have partially or wholly disappeared, and it is suggested that the circulation of water along the fault fissures has removed the carbonates of lime and magnesia from the limestones and left behind the manganese and iron as oxides. The principal objection to this theory is that the amount of manganese in the dolomites which have been analysed is very small—less than ½ per cent. Is it possible that beds much richer in carbonate of manganese, like those occurring in Merionethshire, are present but not exposed?

In these days, when there is a marked recrudescence of old superstitions, not confined to geology, it is interesting to note that Dr. Ball, so far as this district is concerned, attributes the surface inequalities directly to erosion. After pointing out that valleys

[1] Explanatory notes to accompany the Geological Map of Egypt by W. F. Hume, Cairo, 1912.

sometimes coincide with faults he says: "It is important to note that the same fault which coincides with a deeply eroded wadi along one part of its course may cut across a high mountain tract in another part, and frequently at the latter place there is not the slightest change in the contour of the surface to mark the line of fault. Nothing of the nature of a 'rift' is anywhere visible; faults have governed the position of drainage lines in places, but erosion alone has removed the material from the valleys." In discussing the relation of the faults to the Gulf of Suez, which has been regarded as a trough subsidence, he refers to his papers in the GEOLOGICAL MAGAZINE[1] in which he has brought forward arguments in favour of the view that it is a submerged land valley.

Enough has been said to show that this clearly written, beautifully illustrated, and well-printed monograph is an important contribution to our knowledge of the geography and geology of the Sinai peninsula.—J. J. H. T.

II.—A TEXT-BOOK OF GEOLOGY. Part II: HISTORICAL GEOLOGY. By CHARLES SCHUCHERT. pp. viii + 405–1026, xxxvii plates printed in text, text-figures 312–522, and Geological Map of North America. New York, John Wiley & Sons, Inc.; London, Chapman & Hall, Ltd. 1915. Price 12*s.* nett.

THE first part of this text-book, dealing with Physical Geology, was reviewed in the GEOLOGICAL MAGAZINE for September, 1916. Physical Geology is much the same the world over, though certain aspects may be more studied, or certain theories more favoured, in one country than in another. Historical Geology on the other hand, unless it be treated from the view-point of that observer in space whom Suess imagined, almost inevitably takes its colouring from the native country of the historian. This tendency is accentuated, and naturally so, when the exposition is based on lectures to the students of a single university. Above all is the difference marked between an American and a European treatment of the subject. We are therefore not surprised to find in Professor Schuchert's book, embodying as it does a course delivered to undergraduates of Yale, a presentation of historical, or at any rate of stratigraphical, geology, which to one brought up on Sedgwick, Murchison, Geikie, and Prestwich, might almost seem to be the account of another world. We do indeed find such familiar names as Cambrian, Carboniferous, and Cretaceous (and we must rejoice that Professor Schuchert's publishers or his own better judgment have not permitted him to use the Cambric, Carbonic, and Cretacic, which he has long sought to introduce); but even these household words have a novel content. The name Carboniferous has long been restricted by American geologists to the equivalent of our Coal-measures. Then this gave place to "Pennsylvanian", the Lower Carboniferous becoming "Mississippian"; and now the latter is split into an upper system, the "Tennesseian", including all formations from the Kaskaskia

[1] "Origin of the Nile Valley and the Gulf of Suez," GEOL. MAG., 1910, p. 71, and "The Gulf of Suez", GEOL. MAG., 1911, p. 1.

down to the Warsaw, and a lower "Waverlian", continuing from the Keokuk to the unfamiliar Chattanooga. These rather uncomfortable system-names are adopted from Mr. E. O. Ulrich, who, however, spelt them differently. In similar fashion the name "Cretaceous" is restricted by Mr. Schuchert to formations corresponding to our Upper Cretaceous, i.e. down to the beginning of Cenomanian time; the preceding ages, from Albian to Neocomian inclusive, are erected into the Comanchian period, at least so far as North America is concerned.

It may be gathered from the preceding paragraph that, except for the Eras, and to an incomplete extent for the Epochs, Professor Schuchert does not attempt to overcome the difficulties inherent in geographical treatment by any use of universal Time-names. For him such ages as 'Tournaician' [*sic*] or 'Cénomanian' [*sic*] are just as local as the Elizabethan period or the Carlovingian epoch. No living geologist is better fitted to discuss questions of correlation, at all events for the Palaeozoic era, than is Professor Schuchert, and the fact that he is deliberately provincial may be held to indicate that in his opinion the time is even yet not ripe for comparison of the isolated histories with any universal Time-standard. Such an opinion does not well harmonize with the widely held view that the rhythmical movements of the earth's crust are at the base of the whole march of the world and its varying tempo, or with the knowledge we already have of those movements—a knowledge so well illustrated by Professor Schuchert's numerous maps, and emphasized by the varied names that he provides for uplifts and disturbances, such as the delightfully christened Shickshockian. No doubt, as he says, we have still much to learn in Europe as in America; and the more we know the more impossible will be exact correlation of far distant strata. But the practical application of a Time-scale will always help us over many difficulties, and will at least show just where our knowledge is defective.

The book is meant to be a guide for American students, and for such a purpose it seems well adapted. Apparently the students of geology at Yale are not expected to have any knowledge of elementary zoology and botany, and so the lecturer has ever and anon to break the thread of his discourse in order to impart information concerning the anatomy of Mollusca, the origin of lungs, the classification of Pteridophyta, the physiology of Amphibia, amniotic development, human embryology, and other matters properly belonging to other branches of study. However well Professor Schuchert deals with these subjects, the space devoted to them has necessarily to be taken away from stratigraphical geology, and the part that suffers is, as already indicated, the history of other countries. For us on this side of the Atlantic, therefore, the book must serve, not as a text-book for our students, but as a useful conspectus of American geological history. Here the rapid advance has of late introduced so many changes that one is grateful for a handy volume in which to follow the succession of geographical forms, and from which to extract the meaning of Appalachicola, Arikaree, Swearinger, Bertie, Cannonball, Kittatinny,

and Mauch Chunk. One must also be grateful for some admirably written sections on the beginnings of earth-history by Professor Barrell, and for a well-illustrated chapter on Dinosaurs by Professor R. S. Lull. In brief, this is an original and stimulating book, where fact and theory are happily mingled, and the tangled threads of many complicated series of events reduced to an orderly and attractive pattern.

III.—Meteorites: their Structure, Composition, and Terrestrial Relations. By O. C. Farrington. pp. x, 233, with frontispiece and 65 figures in text. Chicago: published by author, 1915. Price 8*s*. 6*d*.

THE absence of a comprehensive and up-to-date book on meteorites has undoubtedly been a factor in confining the interest in this subject to a comparatively small number of geologists. The admirable introduction to this study in the handbook to the collection in the Natural History Museum is of course limited in scope, while Cohen's *Meteoritenkunde*, which was intended to cover the full ground of the subject, was unfortunately little more than half finished at the author's death. Dr. Farrington's book, therefore, fills a gap in scientific literature and will be indispensable to the student who desires a general knowledge of the subject.

The book opens with a discussion of the criteria whereby meteorites may be distinguished from terrestrial material, and emphasis is laid on the superficial and chemical characteristics by which the former may be discriminated when, as is generally the case, the fall has not been observed. Several chapters are devoted to the fall of meteorites, while the succeeding sections are concerned with the form and size of these bodies. As is to be expected, the discussion of the composition and structures is very full, the explanation of the octahedral structure so common in 'irons' and the account of the structures found in 'stones' being admirably lucid. In the description of the mineral species a large amount of space is devoted to the three types of nickel-iron, but this constitutes the least satisfactory portion of the book. Thus plessite is explained by analogy with the system silver-copper, as a eutectic developing probably from solid solution, but no mention is made of the recent metallographic work on the system iron-nickel.[1] The investigations of Osmond and Cartaud, Tammann, and particularly Ruer have shown that γ-iron and β-nickel are isomorphous and that this solid solution on cooling undergoes a number of changes in the solid state. α-iron and α-nickel, the low-temperature forms, also give solid solutions, and kamacite is to be regarded as a nearly saturated solid solution of α-nickel and α-iron, and not, as Dr. Farrington hints, as a compound of constant composition, $Ni\,Fe_{14}$. The only compound in the system has the composition Fe Ni, and tænite is considered to be a solid solution of α-iron and this compound, while plessite is a eutectoid of kamacite and tænite, separating from solid solution.

[1] A useful summary of this is given by Desch, *Metallography*, 2nd ed., 1913, pp. 383–5.

The author uses Rinne's term 'eutropic' in place of 'eutectoid', but this is inadvisable as 'eutropic' had previously been used in another crystallographic sense by Linck in 1896, while 'eutectoid', first suggested by Howe in 1903, has also priority over 'eutropic' (suggested by Rinne in 1905) and has been generally adopted.

For a long time the structure of meteorites was regarded as metastable, as it could be destroyed by annealing and a granular texture—occasionally found naturally—obtained. Recently, however, Benedicks, by very slow cooling, has obtained plessite and reproduced the octahedral structure. Hence the granular structure is to be regarded as metastable, and the difficulty in reproducing the usual meteoric structure is to be ascribed to the low rate of diffusion inhibiting changes in the solid state.

In the chapter on classification the only system given is Brezina's modification of the Rose-Tschermak classification. It would have added to the interest of the book if the author had given his own interesting classification based on the American quantitative system for igneous rocks, and Berwerth's rational system founded on the synthetic work on nickel-iron. The recent genetic one, devised by Prior, was, of course, published after this book appeared.

The illustrations are excellent and the letterpress very clear, though there is a misprint in figure 53 and another on p. 139. The use of such a contraction as 'A.N.H. Wien' is by no means clear. Nevertheless the book can be confidently recommended as the best general introduction to the study of meteorites which has yet appeared, and should be in the possession of everyone interested in the subject.

A. S.

IV.—Radioactivity and Mountain Building.

The Compression of the Earth's Crust in Cooling. By Harold Jeffreys. Phil. Mag., xxxii, pp. 575–91, December, 1916.

THE view that mountain-building owes its principal cause to the contraction of the earth has been widely adopted by geologists. The subsidiary view that the alleged contraction is due to loss of heat has not met with equal success. The calculations of T. Mellard Reade, made before the discovery of radioactivity, indicated that the circumferential shortening of the globe (in cooling from a molten state to its present condition during a period of 100 million years) could not exceed 10·5 miles. This figure is only a small percentage of the shortening implied by the existence of great mountain ranges. Moreover, various calculations of the *level of no strain* by Fisher, Reade, Davison, and G. H. Darwin gave results varying between 0·7 and 7·8 miles. That is to say, compressional deformations of the earth's crust must, on the older hypotheses, have been limited to a thin superficial shell which could never have accumulated the enormous stresses required for periodic mountain-building. Thus, in two directions, the thermal contraction theory was shown to be hopelessly inadequate to meet the facts. Consequently other causes of contraction have come to be invoked in recent years; among them,

a molecular rearrangement of compounds in the earth's interior, which under high pressure may be supposed to involve a decrease in volume.

With the discovery of radioactivity and the realization of its fundamental importance in dynamical geology it became evident that the thermal contraction theory stood in urgent need of re-examination. The mathematical skill required for this task is of an order far beyond the attainments of most geologists, and Mr. Harold Jeffreys has come to our assistance by working out, in the light of our later knowledge, the group of problems involved. Using the thermal and radioactive data adopted by the present writer in a series of papers which have appeared in the pages of this Magazine, he has arrived at the following results:—

(*a*) The level of no strain is now at a depth of 79 km. (uniform distribution of radioactivity) or of 76 km. (exponential distribution).

(*b*) Every great circle of the earth has been shortened by 227 km. (uniform distribution of radioactivity) or by 133 km. (exponential distribution). To arrive at the radial shortening, these figures should be divided by 6·28.

(*c*) The surface of the earth has been diminished by crumpling by $5{\cdot}6 \times 10^6$ sq. km. (uniform distribution of radioactivity) or by $3{\cdot}3 \times 10^6$ sq. km. (exponential distribution).

In order to test these results Mr. Jeffreys has calculated from the mean height of existing mountain ranges the approximate diminution of the surface by crumpling. He finds the amount to be about $1{\cdot}8 \times 10^6$ sq. km., which is little more than half of the amount implied by the thermal contraction hypothesis in its new form (exponential distribution). It should be pointed out, however, that Mr. Jeffreys' calculation of the actual amount of diminution of the surface by crumpling gives only a minimum result, for it does not take into consideration the former existence of ranges that are now submerged or denuded to insignificant elevations. Most of the ranges measured are of post-Carboniferous age, and may therefore represent only a third or a quarter of the total crumpling since geological history began. The maximum circumferential shortening demanded by Chamberlin is about 300 km., corresponding to a surface diminution by crumpling of $7{\cdot}6 \times 10^6$ sq. km., more than twice as much as that found theoretically on an exponential distribution of radioactivity. Nevertheless, in spite of the fact that complete accordance has not yet been attained, it is evident that the theoretical and observed compressions are of the same order of magnitude, and it may confidently be asserted that the much abused thermal contraction hypothesis, thanks to radioactivity, has now been set firmly on its feet.

ARTHUR HOLMES.

V.—Mineral Resources of the United States for 1914.

THIS is the 33rd of the admirable series of reports which was started in the early years of the United States Geological Survey. Year by year they give carefully prepared statistical

information of the output of minerals in the country and of the imports from outside. As usual this report is divided into two main parts, of which the first deals with metallic and the second with non-metallic substances, the latter including fuels, structural materials (other than metals), chemical minerals, and precious stones. Each chapter is entrusted to a different writer, and each is issued separately as soon as it is ready. The date of publication of the several chapters is given on the wrappers, but disappears in the bound-up volume; the pagination is continuous, but separate throughout each part of the report, including the summary. The series is so well known that detailed criticism is uncalled for; it is sufficient to say that the present report is well up to the high standard of its predecessors.

REPORTS AND PROCEEDINGS.

I.—Geological Society of London.

1. *December* 20, 1916.—Dr. Alfred Harker, F.R.S., President, in the Chair.

Marie C. Stopes, D.Sc., Ph.D., gave an account of some recent researches on Mesozoic 'Cycads' (Bennettitales), dealing particularly with recently discovered petrified remains which reveal their cellular tissues in microscopic preparations. To make the significance of the various fossil forms clear, Dr. Stopes first showed some lantern-slides of living Cycads, and then pointed out that it was in their external features and in their vegetative anatomy only that the fossil 'Cycads' were like the living forms; the most important features, the reproductive organs, differ profoundly in the two groups, and the fossils were fundamentally distinct, not only from the living Cycads, but from all other living or fossil families.

The fossils representing the group that are most frequently found are (*a*) trunks, generally more or less imperfect casts or partial petrifactions, and sometimes excellent petrifactions preserving anatomical details and cell-tissues; (*b*) impressions of the foliage. Not infrequent are the detached impressions of incomplete 'flowers' or cones, of one cohort (the Williamsoneæ), while petrified fructifications are numerous in some of the well-petrified trunks of the Bennettiteæ. The described species of the group run into hundreds, but probably many of these duplicate real species, because the foliage, trunks, pith-casts, various portions of the fructifications, etc., have often been separately found and named. In very few cases have the different parts been correlated. The species of the foliage are the most generally known, as they are the most readily recognized with the naked eye; they have been described under a variety of generic names.

The following table gives the proved, or probable, associated parts of some members of the group:—

Foliage.	Trunk.	Fructifications.
Zamites spp.	*Bennettites* spp.	*Bennettites* spp.
Zamites gigas.	Attached, no separate name.	*Williamsonia gigas.*
Otozamites sp.	—	*Williamsonia spectabilis.*
Ptilophyllum pectinoides.	—	*Williamsonia whitbiensis.*
Anomozamites minor.	(Only slender branches known, no name.)	*Wielandiella angustifolia.*
Tæniopteris vittata.	—	*Williamsoniella coronata.*

Dr. Stopes exhibited slides of microphotographs of the stem and leaf-base anatomy of the group, including some unpublished details of *Bennettites maximus*. The roots of the group have hitherto been entirely unknown, and a slide was exhibited for the first time showing rootlets penetrating the leaf-bases of a petrified specimen (represented by a section in the Geological Department of the British Museum—Natural History). These roots probably belong to *B. saxbyanus*: they are covered with wonderfully petrified root-hairs, running uncollapsed through the silica matrix. They raise interesting questions concerning the possible chemical conditions of the infiltration of the silica. Illustrations were also exhibited of the famous complex 'flower' and cone-structures, and of Wieland's brilliant restorations of the same. Microphotographic slides were exhibited of the seed-cone of an interesting unpublished new species from the British Gault. This is beautifully petrified, and adds to our knowledge of the finer anatomy of the seeds and associated structures. It is also the largest cone of the Bennettitales yet known, though it occurs in the Gault, by which time the group appears to have begun rapidly to die out.

The following table indicates the distribution of a few of the most interesting representatives of the Bennettitales (including the cohorts Bennettiteæ and Williamsoneæ):—

Upper Cretaceous.	Very fragmentary and uncertain records; apparently the group is nearly or quite extinct.	
Middle Cretaceous: Gault.	The new large-sized seed-cone. *B. morierei* ♀ (? described originally from the Jurassic).	
Lower Cretaceous: Lower Greensand.	Well-petrified trunks with fructifications. *B. gibsonianus* (type-species of the Bennettiteæ).	
Potton Sands.	*B. maximus.* Trunks, e.g. *Colymbetes edwardsi.*	Throughout these periods in America, trunk-remains very abundant, often petrified and with fructifications, particularly from the Black Hills, South Dakota, and Maryland.
Wealden.	Trunks (casts and petrifactions), foliage. *B. saxbyanus.*	
Jurassic: Purbeck.	Trunks (casts and semi-petrifactions). Buckland's original *Cycadeoidea* spp. *C. gigantea.*	
Oolites.	Trunks, pith-casts, etc. Much foliage of various types. *Williamsonia gigas* and other fruit-impressions. *W. scotica.*	*C. jenneyana*, *C. ingens*, *C. wielandi*, etc.
Lias.	*Williamsoniella coronata.* Foliage and *Williamsonia* fruits (India).	Rich impressions in Mexico of *Williamsonia* and many foliage genera.
Rhætic.	*Wielandiella angustifolia* and foliage.	

The group is by far the most characteristic of all the plants of the Jurassic and Lower Cretaceous, during which periods its distribution was almost world-wide. It was locally, if not universally, dominant, and was the most highly evolved plant-group of the epoch of which we are cognizant.

Three chief points of interest are to be noted in the geological distribution of these plants: (*a*) that the most numerous highly specialized trunks reach their maximum in the Jurassic and Lower Cretaceous Periods, when their distribution was practically world-wide; (*b*) that the oldest and therefore presumably the most primitive type, *Wielandiella*, is externally less like the living Cycads than the commoner later forms, while these latter are utterly unlike the living genera in their fructifications; (*c*) that the geologically youngest cone is the largest yet discovered, occurring in the Gault when the extinction of the group appears already to have set in.

Contrary to what might have been anticipated from their external likeness to the living Cycads, coupled with their great geological age, the fossil 'Cycads' are much more complex and on a higher level of evolution than the living group. It seems to the author to be extremely unlikely that the fossil and the living forms have any direct phylogenetic connexion nearer than a remote, unknown, common ancestor. The mooted connexion between the fossil 'Cycads' and the Angiosperms is highly suggestive, but lacks data for its establishment.

A short discussion followed, and the thanks of the Fellows present were accorded to Dr. Stopes for her lecture.

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2. *January* 10, 1917.—Dr. Alfred Harker, F.R.S., President, in the Chair.

The following communications were read:—

1. "On the Palæozoic Platform between the London Basin and Adjoining Areas, and on the Disposition of the Mesozoic Strata upon it." By Herbert Arthur Baker, B.Sc., F.G.S. With an Appendix by Arthur Morley Davies, D.Sc., F.G.S.

The author carries on the work of Dr. A. Strahan and Dr. Morley Davies in tracing the contours of the Palæozoic platform of the South-East of England. By comparing these with the contours of the base of the Gault, he determines the probable boundaries of the areas of the platform that were only submerged finally under the Gault sea. He analyses the effects of post-Cretaceous tilting and warping, and presents a map illustrating the contours of the Palæozoic floor at the end of the Lower Cretaceous Period.

He next discusses the successive Mesozoic overlaps on the platform, the probable areas that they respectively cover, and the relation of these to the tectonics of the platform itself. He claims that there is evidence for a second Charnian axis, parallel to that traced by Professor P. F. Kendall, proceeding south-eastwards through Norfolk and Suffolk, east of Kent, to the North of France. He further suggests that the area between these two geo-anticlines is a geo-syncline, which in Mesozoic times, in consequence of the accumulation

of sediments within it, and the continued operation of Charnian movement, became converted into an anticline (as in the case of the Wealden area).

In an Appendix, Dr. Morley Davies discusses the interpretation of the Saffron Walden boring, and its bearing on the supposed inter-Charnian trough; he also points out evidence of a post-Cretaceous Charnian anticline under London.

2. "Balston Expedition to Peru: Report on Graptolites collected by Captain J. A. Douglas, R.E., F.G.S." By Charles Lapworth, LL.D., M.Sc., F.R.S., F.G.S.

The specimens of graptolites were collected from the rocks of the Inambari district in Peru by Captain Douglas, under whose name the collection has been placed in the Geological Department of the University Museum, Oxford. These fossils were forwarded by Professor W. J. Sollas to Professor C. Lapworth, who embodied the results of his study in a Report, of which the following is a brief abstract.

The specimens are recorded as all occurring in the same locality, but it is not known whether they were obtained from a single zone. The majority of the rock-specimens in which the graptolites occur are black and somewhat pyritous carbonaceous shales, usually well bedded and uncleaved, and the graptolites are in general well preserved. The lithology of the containing rocks and the mode of preservation of the graptolites are similar to those obtaining in the richest graptolite-bearing strata of Britain, Europe, and North America.

The forms apparently represented in the collection are *Loganograptus logani*, Hall, a new species of *Goniograptus* (?), *Didymograptus stabilis*, Elles & Wood, and *D. bifidus*, Hall, *Phyllograptus angustifolius*, Hall, *Glossograptus acanthus*, Elles & Wood, *Cryptograptus tricornis*, Hall, var. *Amplexograptus confertus*, Lapworth, and *A. cælatus*, Lapworth.

Taken as a whole this graptolite fauna may best be compared with that of the Upper Arenig formation of Britain and its North American equivalents, answering to the Lower Llanvirnian of Hicks & Marr, and the *Didymograptus bifidus* zone of Elles & Wood and H.M. Geological Survey.

The assemblage of graptolites discovered in Bolivia a few years ago by Dr. J. W. Evans corresponds very closely with this Peruvian fauna, and was probably derived from the southward continuation of the same Andean graptolite band. The Peruvian forms in the Douglas Collection, like those from Bolivia, admit almost as close a parallelism with those of the Arenig–Llandeilo graptolite beds of Australia and New Zealand as with their representatives in the Northern Hemisphere.

Not only is the Douglas Collection of Peruvian graptolites instructive and valuable from the palæontological point of view, owing to the number and good state of preservation of the species represented, but it is of especial interest from the palæographical aspect, as affording additional proof of the identity (in general facies) of the graptolite fauna of the sea-waters of Lower Ordovician times

in those regions of the globe which are now occupied by some of the dry lands of Britain, Eastern North America, Peru, Bolivia, Victoria, and New Zealand. Thus it greatly strengthens the inference that in Arenig-Llandeilo times there was open-sea communication admitting of the circulation of sea currents along some as yet undetermined line or lines, connecting the above-mentioned regions, which must have extended across the Equator and apparently throughout a length nearly equal to that of half the circumference of the globe.

II.—Edinburgh Geological Society.

December 20, 1916.—Dr. Flett, F.R.S., President, in the Chair.

The following papers were read:—

1. "Igneous Intrusive Phenomena at Upper Whitfield, near Macbiehill; and at Ravelrig and Kaimes Hill Quarries, Balerno." By T. Cuthbert Day, F.C.S.

The intrusive nature of the Upper Whitfield basalt was established by the discovery of upper and lower contacts with the sedimentary deposits. Details of a xenolithic structure in the igneous rock at the point of contact were given, and a peculiar marmorized dolomite associated with chert was described. Mention was also made of a case of metasomatism in basalt through the action of a deposit of dolomitized calcite.

A description was given of a peculiar tachylite in connexion with the intrusive olivine dolerite at Ravelrig and Kaimes Hill quarries, Balerno.

2. "On a Section in a Bore-hole in the Calciferous Sandstones, Upper Old Red Sandstones, and Lower Old Red Sandstone Lavas in the Grange District, Edinburgh." By D. Tait, H.M. Geological Survey.

Mr. Tait said that the geological horizon of the beds in the upper part of the bore are on the boundary between the Carboniferous and the Old Red Sandstone formations, but, as no fossils had been found in the bore, no sharp line could be drawn at their point of junction; possibly they form passage beds between them, since there were present, interbedded with each other, beds typical of both formations.

At a depth of 284 feet a fault breccia was passed through. This probably indicates a fault, with a downthrow to the south-west, but its importance is not known. From 389 to 397 feet cornstone bands and nodules were found, interbedded with red marly clay. At 399 feet the bore passed through the unconformity between the Upper Old Red Sandstone and the Lower Old Red Sandstone. The Lower Old Red Sandstone rocks are lavas of Blackford Hill Quarry type and a bed, 47 feet thick, of volcanic agglomerate. The total depth of the bore from the surface was 475 ft. 6 in.

III.—The Geological Society of Glasgow.

At a meeting of the Geological Society of Glasgow held on December 14, 1916, Mr. H. R. J. Conacher read a paper on "Oil-shales and Torbanites". The rocks of these types which occur in

the Lothians yield, on destructive distillation, a characteristic crude oil which consists chiefly of paraffins, olefines, and naphthenes, and they thereby differ from ordinary coals, the liquid products of which contain but small amounts of these hydrocarbons. This peculiarity has been variously ascribed to the presence of vegetable matter derived from algæ or higher plants in a more or less decomposed state, animal matter from the fish, ostracods, etc., whose remains are abundant in the shales, to the presence of petroleum or other bituminous substances or to a hypothetical material called kerogen. The author described a series of experiments undertaken with a view to attaining a definite result, the method being to ascertain what material could actually be detected by means of the microscope, and to compare these constituents with the results of the distillation of the same samples.

In those shales which contain animal remains, the yield and quality of oil is independent of the amount of animal remains, but varies in proportion to the quantity and nature of the vegetable matter present. The latter consists of two distinct types. One portion seems to be macerated and carbonized plant-material, similar to that of which coal is composed, while the other portion is composed of certain yellow bodies which have been variously described as spores, fossil algæ, or globules of dried-up petroleum. It is these yellow bodies which yield the distillation products of oil-shales and torbanites. The evidence is against these bodies being spores, algæ, or petroleum, and it is shown that they are simply fragments of resin set free by the decay and oxidation of woody matter with which they had been originally associated, and that, by the physical action of pressure and shrinkage, structures had been developed simulating those of spores and algæ. The failure to obtain appreciable amounts of extract by means of the usual solvents is inconclusive, as it is known that the solubility of resins rapidly diminishes with increasing age. Further it has recently been found that the resinous material extracted from coal yields on distillation just such products as are got from oil-shales and torbanites. The author's view, therefore, is that both oil-shales and torbanites are derived from the same original materials as ordinary coals, but have reached a state of more complete elimination of the perishable parts, leaving the resins with a proportion of material derived from the decomposition of the woody substances, which in the case of oil-shales are mixed with a large proportion of mud.

Mr. J. Neilson read a paper entitled "The Auld Wives' Lifts, an Ancient Monument". He objected to the view that these stones had reached their present position through natural agencies by the subaërial weathering of a ridge, as the position of the stones in the centre of a shallow amphitheatre rendered the action of erosion negligible, while the surrounding rocks show little sign of alteration since Glacial times. The theory that their origin is due to ice-action is equally untenable, while there are likewise difficulties in the hypothesis that the structure is a "tor". The explanation advanced by the author is that the "Lifts" did not attain their present position by natural agencies, but that they were placed there by man, the

blocks having been taken from the nearest escarpment. The whole structure belongs to the type of monument known as cromlech or dolmen, and the irregular form and small dimensions are probably to be explained by the fact that the chief consideration was the feat of raising the enormous blocks, the utility of the chamber beneath being of secondary importance.

CORRESPONDENCE.

PROFESSOR LOEWINSON-LESSING.[1]

Sir,—It was arranged in January, 1914, that a German translation of Professor Loewinson-Lessing's important memoir on the volcanoes of the central Caucasus should be published in Tschermaks Mitteilungen. Owing to the strike of the printers in Vienna the publication of the memoir was delayed till the summer, and before its issue war was declared. It has subsequently been published, and Professor Loewinson-Lessing is anxious that it should be understood by his English friends and fellow-geologists that the publication of this memoir in Austria was arranged *before the War* and that he has since then had no share in its production.

As Professor Loewinson-Lessing has asked me to explain why his memoir has appeared in an Alien journal during the course of the War, I shall be much obliged if you would issue this explanation.

J. W. Gregory.

Geological Department, University, Glasgow.
January 17, 1917.

OBITUARY.

ERNEST SWAIN.

Born January 15, 1843. Died December 20, 1916.

Although he never contributed to any scientific publication, Ernest Swain was well known to a past generation of geologists as a keen student of the science and a constant attendant at the meetings of the Geological Society and Geologists' Association. Of the latter he remained a member till the last.

He was born at Wood Lane, Shepherd's Bush, and educated privately and at King's College, of which he became an Associate. His life was passed in business in the West End, but all his spare time was devoted to scientific studies, and his museum and library were open to all friends and students, many of whom owed their start on a scientific career to his influence and aid. He was an active member of the quondam West London Scientific Association and the succeeding Western Microscopical Club. He devoted much time to the compilation of commonplace books, of which he kept some 140 going on the subjects that interested him. Unhappily he latterly met with bad times and retired to Chorley Wood, where he died at the close of last year.

[1] Professor of Mineralogy and Geology in the Polytechnic Institute, Sosnovka, Petrograd, Russia.

REGINALD COOKSEY BURTON,

B.Sc., F.G.S., Assistant Superintendent Geological Survey of India.

BORN MARCH 10, 1890. DIED OF WOUNDS APRIL 9, 1916.

THE name of R. C. Burton has to be added to the "Roll of Honour" of geologists who have given their lives for their country in the present War.

Dr. H. H. Hayden, the Director, writes: "Mr. Burton joined the Department in January, 1912, and was posted to the Central Provinces, where, during his short period of service, he did admirable work in helping to solve the question of the origin of the calcareous gneisses which constitute such an important element of the Archæan group of that area. His investigations into the origin of the bauxite of Seoni and adjoining districts also gave evidence of marked ability, and by his death the Geological Survey has lost one of the most promising as well as one of the most popular of its younger members. Mr. Burton joined the Indian Army Reserve of Officers early in April, 1915, and after a short training in India was attached to the 104th Rifles in Mesopotamia, where he died on April 9, 1916, from wounds received in action on the previous day. His loss is keenly felt by all his colleagues." (Records of the Geological Survey of India, vol. xlvii, pt. iii, p. 143, August, 1916.)

SIR EDWARD BURNETT TYLOR, KNT.[1]

J.P., D.C.L., LL.D., F.R.S., Hon. Fellow of Balliol College, and Emeritus Professor of Anthropology, University of Oxford.

BORN OCTOBER 2, 1832. DIED JANUARY 2, 1917.

THIS famous Anthropologist was born at Camberwell October 2, 1832, and educated at the school of the Society of Friends, Grove House, Tottenham, to which Society his family belonged. He was one of the sons of the originator of the old firm of Tylor and Sons, Brass-founders, Newgate Street, E.C., of which his brother Alfred Tylor, F.G.S., was for many years chief. Abandoning business E. B. Tylor devoted himself to the study of the races of mankind, their history, languages, and civilization, and had the advantage, at 24 years of age, to accompany his friend Henry Christy on a journey in Mexico in 1856; the archæological objects then collected now form part of the Christy Collection in the British Museum. His researches are embodied in *Anahuac, or Mexico and the Mexicans* (1861), *Researches into the History of Mankind* (1865), and *Primitive Culture: Researches into the Development of Mythology, Philosophy, Religion, Art, and Custom* (2 vols., 1871; 3rd ed., 1891). He was elected a Fellow of the Royal Society in 1871, Honorary LL.D. St. Andrew's (1873), and D.C.L. Oxford (1873). In 1883 he was appointed Keeper of the Oxford University Museum, Reader, and in 1896 the first Professor, in Anthropology. In 1858 he married Anna, daughter of the late Sylvanus Fox, of Wellington, Somerset, to which place he retired after resigning his post at Oxford. He received the honour of knighthood in 1912.

[1] See also *Nature*, January 11, 1917, p. 373.